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**VIDEO TAPE RECORDING AS A TECHNIQUE
FOR PERSONNEL SUBSYSTEM
TEST AND EVALUATION**

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FOREWORD

This report was prepared by the Human Performance Laboratory of the Engineering Psychology Department, McDonnell Douglas Corporation, St. Louis, Missouri. This project was conducted for the Personnel and Training Requirements Branch Training Research Division, Air Force Human Resources Laboratory, Wright Patterson Air Force Base, Ohio. Charles O. Hopkins was the study manager. Cyrus D. Crites was the principal investigator. The research was conducted under Contract F33615-68-C-1476 during the period 15 May 1968 through 15 July 1969. This report was submitted by the author on 20 September 1969.

The research was conducted in support of Project 1710, "Human Factors in the Design of Training Systems," and Task 171006, "Personnel, Training and Manning Factors in the Conception and Design of Aerospace Systems." Dr. Gordon Eckstrand (HRT) was the Project Scientist and Mr. Melvin T. Snyder (HRTK) was the Task Scientist. Mr. J. Peter Kincaid (HRTK) served as the contract technical monitor.

This project deals with three techniques developed for Personnel Subsystem Test and Evaluation. This document defines the video tape recording technique, the other two are described in AFHRL-TR-69-16 "Miniature Event Recording as a Technique for Personnel Subsystem Test and Evaluation," and AFHRL-TR-69-17 "Press Camera with Polaroid Back Technique for Personnel Subsystem Test and Evaluation."

The author wishes to thank government and contractor personnel of the F-4E Category I, II, and III tests for their participation in this research. Significant contributions in the form of written procedures for assembly, check-out, operation, and maintenance of the video tape recording system were made by John Gunnarson.

This technical report has been reviewed and is approved.

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ABSTRACT

A study was performed to develop new Personnel Subsystem Test and Evaluation (PSTE) techniques for use during Categories I, II, and III Testing of ground operator and maintenance type functions. This report is concerned with the development, modification, and refinement of a video tape recording system as a PSTE technique. Equipment and operational procedures developed for the technique were evaluated under various conditions including Category II Testing at an Air Force Base. Results showed the utility of the video tape recording technique for design and procedures development and training functions as well as for PSTE. Specific recommendations are given for efficient use of this technique from system concept through operational use.

SUMMARY AND CONCLUSIONS

Problem: The human component of complex Air Force weapon systems constitutes a vital part of the system. If such things as personnel manning, or human engineering of the system are done haphazardly, the efficiency of the system will be degraded, cost of carrying out the system's mission will go up, and personnel operating and maintaining the system might even be placed in danger. To guard against mistakes like this occurring and to insure that Air Force systems are well designed from the human standpoint, systems under development are subjected to a process known as Personnel Subsystem Test and Evaluation (PSTE). The purpose of PSTE is to check the various Personnel Subsystem elements (e.g., Human Engineering, Qualitative and Quantitative Personnel Requirements Information, Training Equipment) for their adequacy during various stages of system development (Category I, II, and III testing). In principle, the PSTE process should insure that systems are well designed from the human factors standpoint. In practice, PSTE has not always been effective. One reason for this is that PSTE has usually been concentrated late in the system development process (e.g., Category II Testing). By this time system design is frozen to the extent that changes are enormously costly and time-consuming. Changes are generally instituted only when a safety problem exists, or when modification in a training procedure seems practical. Another reason for this is that the measurement tools used for conducting PSTE have typically been restricted to interviews, checklists and questionnaires. These methods do not yield very good data about humans performing in a systems context. The research problem, then, was to develop a number of PSTE techniques that objectively measure human performance in a systems environment. Further, it had to be demonstrated that these techniques as used in a field system testing exercise could impact system design. To do this, the techniques had to be applied in situations before design is completely fixed and they had to produce convincing enough data to persuade design engineers, category test officials and System Program Office (SPG) personnel to institute design and/or procedural changes.

Approach: Three techniques were chosen for development and field testing. Besides video tape recording, these included a press camera with a Polaroid back (covered in AFHRL-TR-69-17) and a miniature event recorder (AFHRL-TR-69-16). The systems selected as test vehicles (various models of the F-4 aircraft) were undergoing Category II Testing at Edwards AFB, California and Nellis AFB, Nevada. Subsystems dealt with during the study included the AN/APQ Radar, the Martin Baker Mark H7 rocket ejection seat and the Rockeye MK20 bomb. Tasks evaluated using the video tape equipment included such things as weapons hanging, maintenance of the Martin Baker seat, a trial installation of a development stage missile, and technical order validation. Because the F-4 is an aircraft that has undergone a number of model changes, it was considered as a good system on which to probe the limitations and uses of video tape recording as a PSTE tool. Thus, design and procedure change recommendations could be incorporated into later models. The video tape recording equipment was specially modified at the contractor's facility for portability and ease of operation required for efficient data gathering in the system test situation (which is characterized by a requirement for quick reaction). The principal investigator spent a total of four months at Edwards AFB (during this time traveling to Nellis AFB). The purpose was to record test situations that had implications for human factors design, and to convince the various people responsible for system testing and design (e.g., major air commands, SPO, testing and contractor personnel) of the value of the technique.

Extensive field evaluation of the technique was accomplished because this was the only way to demonstrate that the technique was valuable for carrying out its intended purpose, and to probe the limits of its usefulness. A detailed procedure describing the particular configuration of the video tape equipment used in the research effort and procedures for its field use are contained in the appendix.

Results: Video tape recording proved to be a valuable PSTE tool over a rather diverse range of uses that were covered in the study. To give an example, an AGM65A launcher with dummy missiles attached was mounted on the wing of an F-4E aircraft and the activity was recorded on video tape. There was difficulty in this operation and none of the personnel concerned with the test could determine the nature of the problem. However, careful study of the video tape recording revealed a number of problems with the procedures, and some minor equipment design problems. These problems could be determined on the spot and remedies taken immediately so that valuable testing time was not wasted. Further, a record of the procedure was available for use by engineers, technical writers, and training personnel. This particular task was also filmed but the video tape recording proved to be superior in at least two respects. The video tape provided immediate playback capability and a fuller range of events of concern to PSTE personnel than did the film. There are a number of other examples of the value of this video tape recording in impacting system design in the full report. The study indicated that the video tape recording technique has the following characteristics: (1) It can objectively measure human performance. (2) It can provide data that is useful to a system test effort. (3) It produces very little interference with the ongoing test effort. (4) It can be used to provide useful data with regard to a wide number of subsystems and systems operated over a wide range of conditions. (5) It provides a rapid playback capability. (6) It can generate data that is useful in modifying equipment design to result in more efficient, safe and less expensive maintenance and operation. It can result in improved procedures. (7) The video tape recording can be used as a training aid. (8) A video tape recording of Air Force personnel operating equipment under field conditions provides very convincing evidence in the case when equipment design or procedures need modification. (9) The video tape equipment can be relatively inexpensive (as low as several thousand dollars, including all costs connected with its use over a period of several years). It can be portable and is easy for untrained personnel to learn to use. One area that needs further investigation is how to extract certain types of information from the recording for distribution to the correct, responsible organizations. The general problem of retrieving and reducing data from video recordings needs to be further investigated.

Conclusions: The use of video tape recording as a method of assessing performance in the context of system testing has been demonstrated to have real potential. There are a number of inexpensive, easy-to-use video tape recording systems which should be made available to PSTE personnel at the test sites and at contractor facilities. A particular effort should be made to institute the human factors testing program as early in the system development process as is possible. This is the most cost-effective way systems can be well designed from a human factors viewpoint.

This summary was prepared by J. Peter Kincaid, Personnel and Training Requirements Branch, Training Research Division, Air Force Human Resources Laboratory.

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LIST OF ABBREVIATIONS

AFFTC	Air Force Flight Test Center
AFR	Air Force Regulation
AFSC	Air Force System Command
AFSCM	Air Force System Command Manual
AGE	Aerospace Ground Equipment
AGERDS	Aerospace Ground Equipment Recommendation Data
ATC	Air Training Command
BIT	Built In Test
CRT	Cathode Ray Tube
CTCI	Contract Technical Compliance Inspection
ECP	Engineering Change Proposals
FTT	Directorate of Flight Test
FTO	Fighter Operations
LRU	Line Replaceable Unit
MDC	McDonnell Douglas Corporation
NCO	Non Commissioned Officer
PS	Personnel Subsystem
PSO	Pilot Systems Operator
PSTE	Personnel Subsystem Test and Evaluation
QQPRI	Qualitative and Quantitative Personnel Requirements Information
SCD	Specification Control Drawings
SPO	System Program Office
TAC	Tactical Air Command
TCTO	Time Compliance Technical Order
T.O.	Technical Order
VTR	Video Tape Recorder
VTVM	Vacuum Tube Volt Meter

SECTION I

INTRODUCTION

PROBLEM

The Air Force Personnel Subsystem Test and Evaluation (PSTE) programs have been hampered by two problems: (1) PSTE equipment has not always been adequate, and (2) PSTE has sometimes been thought of as an isolated element that is tacked onto the end of system development.

In part, the first problem is a carry-over from the time when human engineering was directed primarily toward air crew/cockpit evaluation. Emphasis was placed on problems such as oxygen consumption, toxic gases, vertigo, and night vision. Most of the equipment required was specialized for measuring a specific substance or physical value.

With the advent of the total system concept, many of the techniques and equipment used for air crew/cockpit evaluations were retained and redirected toward maintenance. However, these methods do not provide the broad approach required for evaluating human performance in the system.

The inadequacies of currently used PSTE techniques are aggravated in most Category test situations by the conditions of understaffed PSTE teams and the great quantity of system personnel, equipment, and procedures to be evaluated.

Concerning the second problem, in a well conceived and executed Personnel Subsystem (PS) program, PSTE is not treated as an isolated element. Rather, PSTE is tied into human engineering and life support, training and training equipment, qualitative and quantitative personnel requirement information, and personnel-equipment data. Even when the system is considered as being operational, the knowledge gained in these efforts is applied to Engineering Change Proposals (ECP's), later models, and advanced design projects.

PSTE planning should concentrate on those systems, subsystems, and components most likely to cause problems when user personnel operate and maintain them. This basic problem-solution orientation requires quick and accurate identification of critical tasks.

PURPOSE

The purpose of this study was to identify, develop and assess new devices, instruments, and techniques for making PSTE a more effective process.

APPROACH

The approach to the solution of the PSTE problems consisted of the following steps:

- a. Selection of two subsystems to be used for validation of new PSTE techniques.

- b. Study of selected subsystems to identify major points and conditions where PSTE of ground operator and maintenance type functions should be accomplished.
- c. Evaluation of techniques and equipment that would have the potential for improving PSTE, and selection of three that seemed to be most promising.
- d. Development of selected techniques and equipment with modifications and additions to make them fieldworthy.
- e. Development of test guides for implementation of the techniques to specific subsystems under category test environment. These test guides specified the test criteria, step-by-step instructions, and treatment of data.
- f. Application of the techniques to the category testing of two subsystems.
- g. Assessment of the value of the techniques to PSTE, PS elements, the test effort, and the potential of the techniques in evaluating early design and development.
- h. Identification of the unique capabilities of the techniques in contrast to standard PSTE practices.
- i. Definition of further advancement in the techniques in terms of modification and application.

During the early phases of the study, two kinds of activity were carried out simultaneously and in parallel. One was the sequence of events concerned with selection and development of new PSTE techniques, and the other was concerned with the study of two current aircraft systems upon which to apply the techniques under category test conditions. The detailed steps in the approach are shown in Figure 1.

OVERVIEW

The results of most PSTE programs have indicated that the total requirements for PSTE, as defined in AFSCM 80-3, AFR 30-8, and AFR 80-14, exceed the capabilities of the normal staffing of the PSTE team. At the same time, however, there is general agreement among test personnel that an expansion of PSTE is warranted.

In the past the pilot/cockpit evaluation has received most of the PSTE teams' attention and effort. An important reason for this emphasis was the concentration of human factors personnel on the aircraft operator functions. Another reason was that Air Force Systems Command (AFSC) pilots and engineers have been highly trained in investigating aircrew/cockpit and flight problems. Therefore, the reporting system in this area has been adequate. This should not be construed as being over-evaluation.

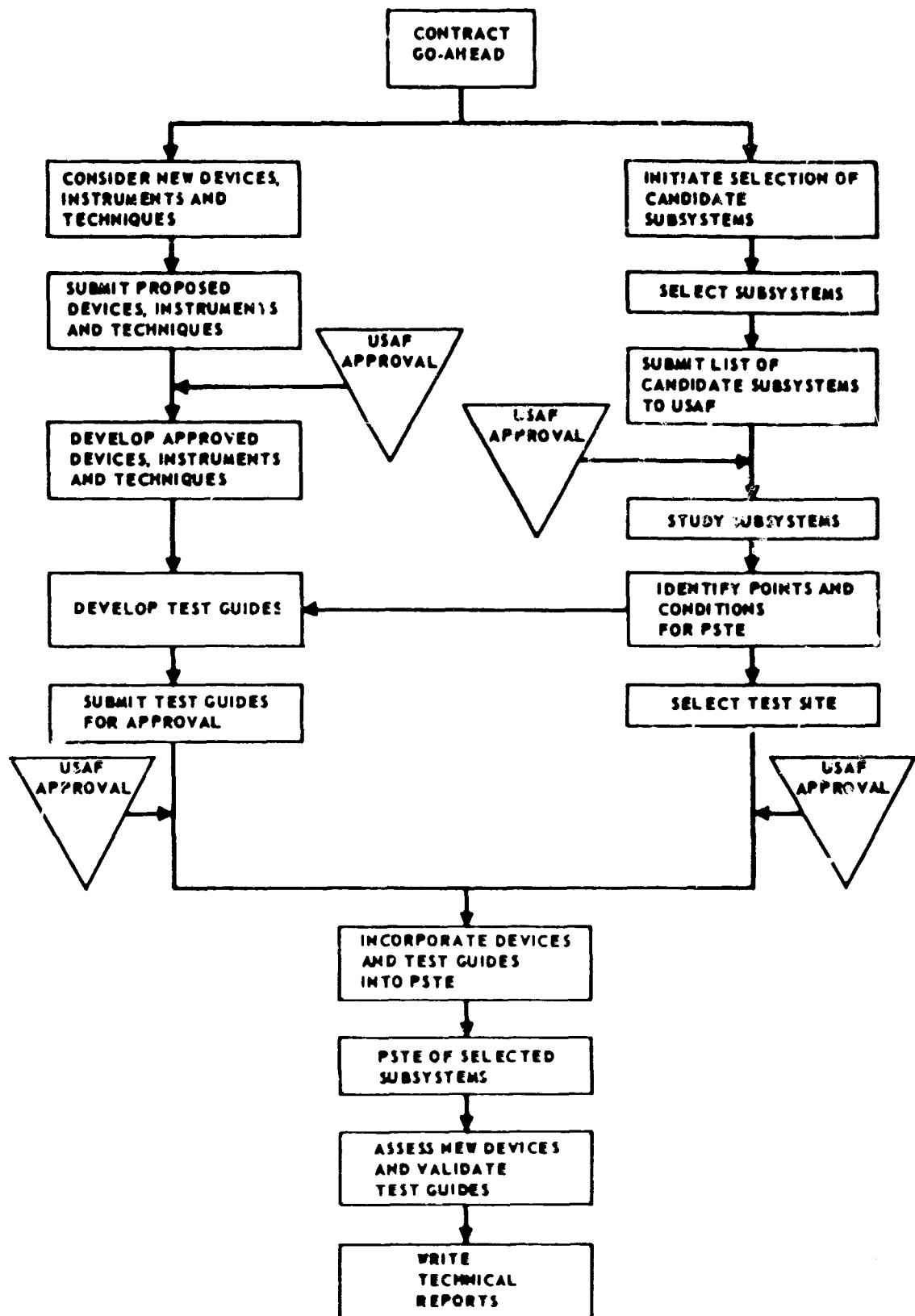


FIGURE 1. THE TECHNICAL APPROACH USED IN THE STUDY

However, it is apparent that maintenance, technical publications, AGE, maintenance training, and maintenance training equipment have not received adequate evaluation. Maintenance is a difficult area to evaluate. Perhaps this is one reason that it has been avoided. Serious and obvious maintenance problems get reported, but there are numerous others that are unreported and poorly identified.

This study was designed to improve the ability of the PSTE team to isolate, identify, report, and solve maintenance problems.

At this time PSTE is a reactive process, only working in those areas where problems have been reported. This approach presumes that the maintenance and air crew personnel are thoroughly familiar with what constitutes a PSTE problem. To a limited extent this approach has been successful, and the results have been significant. However, this approach to PSTE does not provide for the methodical wringing out of the system in the manner of engineering and other test disciplines. Results often verify a problem, but seldom identify one through analysis. Procedures, equipment, and manning are accepted at face value with only token attempts to assess them from the viewpoint of maximum effectiveness. It is true that PSTE has had growing pains, and it has been better to achieve success on a limited basis than to try to evaluate the whole personnel subsystem and fail.

Field experience indicates that there is an approach that would provide for more effective utilization of PSTE manpower and a more methodical and complete evaluation of the PS elements. This is the development of new techniques and their associated equipment. The selection, development, and application of these techniques would be based upon their improving the efficiency and approach of the PSTE team. To this end a series of criteria were developed to select the candidate techniques.

The three techniques chosen were: a video tape recorder (VTR) system, a 4" x 5" Crown Graphic camera with a Polaroid back, and a miniature eight channel event recorder.

The video tape recording system is composed of three basic units: a television camera, a magnetic recorder that is capable of reproducing picture and sound, and a monitor that displays the television image. This system is similar to those used by the television networks for pre-recording programs for later playback. Some of the major advantages of this system are:

- Full hour of uninterrupted recording capability of picture and sound
- Quick playback of recording to assess results, making it possible to retake poor shots and evaluate critical tasks
- No processing is required
- Relatively easy to operate and to assess results
- Reclaimable tape that can be used many times

The equipment used in this study was in the inventory of the McDonnell Douglas Human Performance Laboratory prior to the beginning of the contract. Therefore, no special procurement of the basic equipment was required. All of these items were commercially available, off-the-shelf equipment. This equipment was modified to make it fieldworthy and capable of fast reaction. The modifications are described in Appendix II.

Certain principles of operation and technique identified during the equipment development will be of value to human factors personnel that have limited or no experience in field operations. Most of the modifications were based upon conditions known to exist at Air Force Bases such as the accessibility of power outlets, the adequacy of ambient light, and the requirements for mobility.

These modifications were tested at the hangars and shops of the McDonnell Douglas Facility in St. Louis, Missouri. Further modifications were made when unsatisfactory or marginal results were obtained.

Test guides were developed for the implementation of the techniques. These test guides define the objectives, criteria, and procedures necessary for operation and verification of the techniques at the test site.

Several trips were made to the Air Force Bases that had F-4 test projects in progress. The study was discussed in depth with the various test management personnel. A high level of interest was shown by the test directors. All of them indicated that their test teams would cooperate in implementing the study.

The test site selected for the implementation of the study was the F-4E Category II test at Edwards Air Force Base, California.

The equipment was shipped to the test site in mid-November 1968 and was used there for a period of four months. A trip was made to Nellis Air Force Base during the field study to evaluate ordnance handling.

During the verification period, the techniques were used for the FSTE of two subsystems: the AN/APQ 120 radar, and the Martin Baker Mark H7 ejection seat. In addition, the technique was applied to various other systems and subsystems.

The results of applying these techniques to the subsystems are described in Section IV. The assessment of the technique is discussed in Section V. In addition, the application of the VTR technique to earlier design and development phases is covered. The potential of the VTR technique is dependent to an extent on the further developments of the equipment and suggested features are described.

SECTION II

METHODS

This section describes the selection of techniques and equipment, the development of the selected equipment and fieldworthy devices, and the plans for applying the techniques to the subsystems in an actual test program. The methods were based in part upon experience gained while implementing PSTE on four weapon systems: the F-4C, F-4D, RF-4C, and F-4E aircraft.

SELECTION OF TECHNIQUES

The great variety of available off-the-shelf equipment and known techniques made it necessary to develop selection criteria in order to choose equipment which offered the most potential.

The following criteria were used:

Will Objectively Measure Human Performance

Assessment of human performance is essential to PSTE just as equipment performance measurements are essential to engineering. To be realistic, PSTE during category testing does not lend itself to as fully objective measurements as does a laboratory situation. It is usually impractical to attach measuring instruments directly to the maintenance personnel. However, the techniques should provide firsthand data in terms of time, distance, anthropometry, and task difficulty.

Will Provide Data That is Useful to a System Test Effort

Data collected for PSTE purposes usually is of importance to other test sections, and the valid interpretation of tasks may call for multidisciplinary interpretation. The test director, officers, engineers, and maintenance personnel need and use PSTE data. The form of data is important too, for it may facilitate the understanding and reporting of the problems.

Can Be Used During Test Activities

The technique should be adaptable to hangar, flight line, hot line, and shop environment.

Will Produce Minimum Interference with Test Activities

Aside from slowing down the maintenance effort, interference can lead to invalid information. The techniques should not require special scheduling of maintenance tasks which interrupt the normal work. Extensive instrumentation of man or equipment cannot be made because of safety, job efficiency, and interference factors.

Have a Potential of Being Frequently Used and Applicable to Many Subsystems

Many pieces of equipment have useful applications but are limited to very specialized hardware and human performance areas. For example, the precise measurement of illumination is very useful but has very limited application to all PS elements or to many subsystems, especially in regard to maintenance functions. Techniques having a broad application in category testing may also be valuable in the earlier design and development phase.

Will Be Based on the Technique as Being a PSTE Tool in Contrast to a Research and Development Tool

It is too late in the system development cycle for hardware development to take place at a category test site. The identification of toxic compounds, hazardous noise, and electrical shock hazards should have been detected earlier in the PS effort. Therefore, PSTE, to be most effective, should concentrate on assessing the people working with the equipment and not on developing an alternative design. That is, it should be geared toward the assessment of human performance in a systems context.

Can Be Used By Test Personnel Without Extensive Training

The composition or capabilities of future PSTE teams cannot be determined. Therefore, the techniques should not call for a very high skill level, or a large amount of prior knowledge.

Will Generate Data That is Usable by SPO's, Contractors, and the Air Force Commands

Communication between the test site and all interfacing military and contractor groups is a severe problem. The data emanating from the technique should aid in the understanding of the problems and not require interpretation by experts. Any method that would speed and enhance understanding would receive special attention.

Will Be Adaptable to a Fast Reaction Situation

A category test is geared to a schedule, and maintenance tasks are performed as soon as practicable. In addition, most maintenance is based on failures, and one cannot anticipate in advance what is going to fail. Therefore, PSTE equipment that requires extensive hook-up time, calibration, and preparation would not be desirable.

Will Provide Results That Have Operational Significance

If the techniques can identify the relationship of the task to launch time, turn-around time, operational ready status, and ordnance uploading and downloading they should be given special consideration.

All of the preceding criteria were established to provide a better means for achieving the formal PSTE requirement as defined in AFR 30-8: "Determine the adequacy of the personnel subsystem and accelerate actions when changes in personnel training and/or manning for the system in its operational environment are required. Verify that the personnel subsystem is adequately supported by equipment design, tools, technical data, job environment, training equipment, personnel selection, manning, and organizational control procedures."

The candidate techniques were assessed as to their capabilities in regard to applying them to PS elements, requirements known from field experience, and the selection criteria. Out of a considerable field, three techniques were chosen for submittal to the technical monitor for approval.

- a. A video tape recording system composed of a television camera with lenses, a video tape recorder, and a television monitor. Supporting the basic equipment were various ancillary items such as a tripod, lights, cart, and electrical cables required to operate the system.
- b. A miniature 8 channel event recorder with battery pack, and an 8 channel switch box.
- c. A 4" x 5" Crown Graphic camera with a Polaroid film back.

These three techniques were accepted by the technical monitor for development and field validation.

The system equipment is described in general terms in Section III and the complete operating instructions are presented in Appendix I. The technical data of the off-the-shelf equipment is listed in Appendix III.

SELECTION OF TEST SITE

The value of the selected PSTE techniques was to be determined through their use in an ongoing category test.

The Engineering Psychology Department at McDonnell Douglas has the responsibility of implementing the personnel subsystem program on the F-4 aircraft. Although the F-4C, RF-4C, and F-4D weapon systems had been developed with PS programs, all of these were operational at the time of the study proposal. However, the F-4E aircraft was in Category I, II, & III testing. In addition, several major equipment modifications and additions to the F-4E were being considered or in the process of being developed.

The testing of the F-4E was being carried on at three different bases. The Category I test was being conducted at the McDonnell Douglas Facility at Edwards Air Force Base (AFB), California. The Category II test was being conducted by a joint AFSC and Tactical Air Command (TAC) test team at Edwards AFB. The Category III conducted primarily by TAC was at Nellis AFB, Nevada and at Eglin AFB, Florida. Several trips to each of these bases had been made

for PSTE purposes. Once the study was underway, additional trips were made to discuss the objectives, scope, and requirements of the study. The management of each of the three tests was interested in the techniques, and understood the difficulties in evaluating maintenance. They were especially helpful in defining the tests that would be applicable to this study.

Selection of the test test site for the study was based on a review of the potential benefits as well as the possible problems. At the time that the category test site was being selected, the following assessments were made:

a. Edwards Air Force Base, F-4E Aircraft Category II Test.

This F-4E system and performance test was in its second year of testing. A formal PSTE program was being implemented by a team composed of AFSC officers, Air Training Command Noncommissioned Officers (ATC NCO'S), and contractor personnel. The management of the test team and all test sections were familiar with PSTE so no indoctrination would be required. The test program was not under outside pressure so that tests were not under stress. Because the tests involved performance verification, primarily, the acceptance of new techniques in PSTE would not create too much concern.

In addition, the F-4E Category I test was being conducted at the McDonnell Douglas Facility at Edwards AFB and might provide some basis for evaluation of activity at an earlier stage of equipment development.

On the negative side, the volume of maintenance was very low because there were only two F-4E aircraft in system test, and one of these did not have a radar subsystem. The maintenance was being performed by AFSC, TAC, contractor, and vendor personnel. These men would not be representative of an operational unit because their skill level was higher. However, this is a situation common to most Category tests. The training, training equipment, and Qualitative and Quantitative Personnel Requirements Information (QQPRI) Personnel Subsystem (PS) elements could not receive attention because F-4E training was not being conducted at this base. Also, the logistic supply situation was not typical at Edwards AFB.

b. Eglin Air Force Base, F-4E Aircraft Category III Test.

The Category III testing on the F-4E was drawing to a close as this study began. However, operational testing was scheduled to continue during the study period in a series of 'follow on' tests without the title of Category III testing. The 33rd Tactical Fighter Wing of F-4E's was based at Eglin AFB and training was still being conducted. Because of the large volume of maintenance, maintenance personnel, and the use of operational procedures, this site offered the most realistic operational environment outside Southeast Asia.

The 33rd Tactical Fighter Wing was preparing for deployment and because of the urgency of this preparation certain maintenance functions were being accelerated. In addition, the injection of untried techniques into a stressful situation could have created some resentment. Since PSTE was not being

implemented on this program there was no established base from which to work, and no provisions for reporting results.

c. Nellis Air Force Base, F-4E Aircraft Category III Test.

This test site was also being used as an F-4E Category III test site. The Category III test management and some personnel were spending time at both Nellis and Eglin Air Force Base. There was a greater volume of maintenance activity at Nellis than at the Category II test at Edwards AFB, but less than that at Eglin Air Force Base. The Nellis operation did not have a PSTE effort. The F-4E training and training equipment were not on site.

d. Recommended Test Site.

On the basis of the on-site evaluation of these category tests the following recommendations were made to the technical monitor of the study.

- (1) The current Category II test on the F-4E at Edwards AFB will continue for several more months and will afford a sound basis for equipment evaluation under testing conditions.
- (2) The F-4E Category II test personnel at Edwards AFB concur that this study would be useful to their effort and will cooperate in implementing the study.
- (3) The McDonnell Douglas Corporation (MDC), Edwards AFB Facility, offers additional potential with its F-4E Category I effort, and F-4C/D/J/K/M and RF-4C/B testing. MDC personnel could use results directly to aid in design changes.
- (4) The Directorate of Materiel, Edwards AFB is interested in this study, and will cooperate in its implementation. The Directorate can provide for evaluation of aircraft and subsystems over a wide range of maintenance. In addition, this Directorate is at the highest management level and interfaces directly with the Base Commander.
- (5) Nellis AFB, Nevada is near enough (260 miles) to allow periodic evaluation under Category III conditions, since several F-4E tests would be implemented during the study period. Formal Category III testing for the F-4E has been completed at Eglin AFB, Florida.
- (6) Under the present development of the equipment it is felt that there are some technical problems that could create interference with the rapid pace of the Eglin AFB operation. These technical problems will be solved as part of the study, but it is preferable to avoid the possibility that these deficiencies might degrade operational maintenance.

In summary, Edwards AFB can provide an excellent exposure of the study techniques to the many testing disciplines, and can provide for rapid assimilation of their use into testing programs.

Edwards AFB was approved as the evaluation site by the contract technical monitor.

SELECTION OF SUBSYSTEMS

A crucial factor in the selection of subsystems to be used as evaluation vehicles would be the applicability of study results generally to a wide range of aerospace systems, including aircraft, spacecraft, missiles, and command and control systems. Therefore, the subsystems to be studied had to have general characteristics that elicit: eye-hand coordination, learning, precision of movement, perception, and other elements of human behavior. Specifically, the subsystems had to meet most of the criteria listed in Table I.

In addition, the subsystems would preferably be in Category II or III testing during the validation period.

Hundreds of engineering change proposals were being developed, approved, and implemented on the F-4 series of aircraft. However, some of these changes would not reach the testing stage prior to December 1968. Others did not warrant consideration because of their characteristics, simplicity, or the improbability that they would require maintenance.

TABLE I: SUBSYSTEM SELECTION CRITERIA

1. BE SUFFICIENTLY COMPLEX TO WARRANT EVALUATION (STRUCTURE, ELECTRONIC, HYDRAULIC, PNEUMATIC).
2. REQUIRE DIAGNOSIS OF MALFUNCTION AND REPAIR BEYOND SIMPLE STRUCTURAL FAILURE OR THE OBVIOUS MALFUNCTIONS.
3. REQUIRE AGE FOR MAINTENANCE.
4. HAVE A RELATIVELY HIGH RATE OF FAILURE AND/OR FREQUENT ADJUSTMENTS, AND/OR SERVICING FOR OXYGEN, HYDRAULIC FLUID, AMMUNITION OR FUEL.
5. REQUIRE BOTH FIELD AND ORGANIZATIONAL MAINTENANCE.
6. BE COMPATIBLE WITH SECURITY REGULATIONS SO THAT RESULTS CAN BE PUBLISHED OPENLY.

Two major subsystems that were being developed that met most of the criteria in Table I were: the AN/APQ 120 radar, and the Martin Baker Mark II ejection seat. The AN/APQ 120 radar is a classified subsystem, but it was anticipated that the classified portions of the radar could be avoided in reporting the study results.

a. AN/APQ 120 Radar.

This subsystem represented one of the most modern fire control systems in the Air Force inventory. It was scheduled to be in Category II test at Edwards at least until April 1969. The complexity of the equipment and associated tasks, the importance of the subsystem to mission accomplishment,

and extensive AGE support provided a sound base for a comprehensive evaluation of the new PSTE techniques and equipment. It was anticipated that enough information could be acquired on this subsystem through the use of the technique to form a basis for a thorough evaluation of human engineering, training, and skill level requirements.

b. Martin Baker Mark H7 Rocket Ejection Seat.

This subsystem is replacing the Mark 5 seat which works by gun action alone. The new seat is propelled by gun and rocket power to provide for zero ground, zero altitude ejection capability. The new seat was not scheduled to receive a formal Cat I, II, or III evaluation. However, it was being retrofitted into the Category I, II, and III aircraft. The earlier human engineering evaluation of this seat had identified some maintenance tasks that required evaluation. The maintenance of the seat involved servicing of pyrotechnic devices and a great deal of mechanical mechanisms. Therefore, the selection of this subsystem complemented the electronic characteristics of the AN/APQ 120 Radar.

A listing of the airborne AVE and ground equipment AGE for the two subsystems is given in Tables II through IV. In addition to the equipment list, basic information regarding their design, development, and maintenance procedures was available. Table V is a partial listing of these system development products.

IDENTIFICATION OF POINTS AND CONDITIONS FOR PSTE

The study of the two selected subsystems culminated in the identification of major points and conditions where PSTE should occur. The determination of these points was guided, first of all, by the requirement that PSTE should provide for the PS elements. Secondly, PSTE should provide for an assessment of basic human performance; learning, motor skills, perception, group behavior, precision of movement, and task performance.

During the design and development, both the AN/APQ 120 radar and the Martin Baker Mark H7 ejection seat subsystems received evaluation from the McDonnell Douglas F-4 PS Group. This review of design and monitoring of development resulted in inputs to AVE, AGE, technical publications, and training. Later in development the PS personnel were involved in Category I, II, and III testing of these subsystems. From the data base acquired by this experience, certain points were identified that required further investigation and evaluation.

Some of the most important considerations for identifying PSTE points are: use by the operator (in regard to maintenance this category pertains to AGE); failure diagnosis (built in test, maintenance inspection); trouble shooting at the organizational level; removal of malfunctioning line replaceable unit (LRU); field level repair; installation; and quality control and functional checks.

TABLE II AN/APQ 120 FIRE CONTROL SYSTEM AIRBORNE EQUIPMENT

Part No.

53-870050-21	Antenna
-25	CW Transmitter
-45	Stabilization Assembly
-47	Cable Assembly
-49	Pump Tube Power Supply
-43	Support Structure
-33	Servo Assembly
-35	Microwave Assembly
-37	RT Electronics
-39	Stalo, Pulse
-41	CW Electronic
-23	Computer
-27	Power Supply
-29	Pulse Transmitter
-31	Synchronizer
53-870050-3	Radar Set Control
-5	Radar Test Set Control
-7	Antenna Control
-9	Indicator Control Unit
-11	Pilot Indicator
-13	PSO Indicator
-15	Mount, Pilot Indicator
-17	Dehydrator

TABLE III AN/APQ 128 AGE (ORGANIZATIONAL-FIELD)

ORGANIZATIONAL AGEPart No.

53E340008-1*	Missile Control System Test Set
-7	Accessories Kit
-13	MCSTS Truck
-17	Dehydrator Compressor
-19	Control Monitor
AN/APM-84B	Radar Modulation Test Set
TS-2059/AMM-18	RF Power Test Set
CN-808/A	Voltage Regulator
HD-416A/U	Hydraulic Pumping Unit
486991-110	Missile Interface Test Set
ME-6D/U	Electronic Multimeter
AM/PSM-6	Multimeter
AM/USH-105A	Oscilloscope
803B/AF	Differential Voltmeter
53E340018-1	Extender Bar Slide Rail
53E340013-1	Radar Test Set
53E340014-1	Computer Test Set
53E340015-1	Supplemental Kit
53E150185-1	LCOSS Test Set AN/ASM-238

FIELD AGE

53E34009-1*	Missile Control System Test Bench Set**
-3	Console #1
-5	Console #2
-13	Console #3
-17	Console #4
-19	Console #5
-21	Console #6

* Comprises A Composite Test Facility, Unique and Common AGE

** Some of the organizational AGE is used with bench.

TABLE IV MARTIN BAKER MARK IV SEAT AND AGE

AVE

<u>Part No.</u>	<u>Description</u>
53-820000-1	Rocket Seat Assembly (Pilot's Seat)
53-820000-3	Rocket Seat Assembly (PSO's Seat)

AGE

<u>Part No.</u>	<u>Description</u>	<u>Maintenance Level</u>
		O-Organizational F-Field
32E110077-1	Insertion Device - Strap Fittings	OF
32E110012-1	Insert - Safety, Firing Mechanism	OF
32E110013-1	Adapter Assembly - Ejection Seat Cradle	F
32E110014-1	Alignment Kit - Rocket Nozzle	OF
32E110026-1	Guard - Rocket, Seat Bucket	F
MDE 32365	Canopy and Seat Ejection Mechanism Tester Assembly	OF
MBEU 1925 KU	Torque Wrench	OF
MBEU 1730	Crow's-Foot Wrench	F

TABLE V PSTE INTERFACES WITH SYSTEM DEVELOPMENT PRODUCTS

<u>System Concept, Design, and Development</u>	<u>Standards, Specifications, and Design Criteria</u>
<p>System Analysis</p> <p>Detailed Specification</p> <p>Vendor Proposals</p> <p>Contractual Data Requirements</p> <p>Specification Control Drawings (SCD's)</p> <p>Preliminary Drawings</p> <p>Final Drawings and Drawing Release</p> <p>Engineering Change Proposals (ECP's)</p> <p>Mock-up Reviews</p> <p>Aerospace Ground Equipment Recommendation Data (AGERD's)</p> <p>Simulation Data</p> <p>Delivery Schedules</p> <p>Prototype Equipment</p> <p>Production Equipment</p> <p>Technical Coordination Meetings</p>	<p>Military Standards</p> <p>Military Specifications</p> <p>Air Force Manuals</p> <p>MDC Engineering Procedures</p> <p>Human Engineering Criteria</p>
<u>System Support</u>	<u>Manning</u>
<p>Maintenance Concept</p> <p>Maintenance Evaluation and Report Documents (MEAR's)</p> <p>AGE Conferences</p> <p>Reliability Data</p> <p>Facility Requirements</p> <p>Integrated Logistic Support Management Plans (ILSMP)</p>	<p>QQPRI Conferences</p> <p>QQPRI Documents</p> <p>QQPRI Field Verification</p>
<u>System Test</u>	<u>Technical Orders (T.O.'s)</u>
<p>Acceptance Test Procedures</p> <p>Acceptance Testing</p> <p>First Article Demonstration</p> <p>Contract Technical Compliance Inspection (CTCI)</p> <p>Flight Test Reports</p> <p>Category I, II, and III Testing</p> <p>Personnel Subsystem Test & Evaluation (PSTE)</p> <p>Special Tests</p>	<p>T.O. Validation Demonstrations</p> <p>T.O. Verification Demonstrations</p> <p>Preliminary Technical Orders</p>
	<u>Training</u>
	<p>Training Program Conferences</p> <p>QQPRI Conferences</p> <p>QQPRI Documents</p> <p>Training Plans</p> <p>Training Texts</p>
	<u>Training Equipment</u>
	<p>Trainer Drawings</p> <p>Training Equipment Conferences</p> <p>Trainer Acceptance Conference</p>
	<u>Field Data</u>
	<p>Unsatisfactory Reports</p> <p>Accident Reports</p> <p>Maintenance Reports</p>

Timing of PSTE has been found to be an important factor in its implementation. The earlier a PSTE team is informed of impending maintenance, the better could be the planning for its assessment. Maintenance has been scheduled on the basis of aircrew debriefings, post flight and preflight inspection, functional checks, or periodic inspections. Except for periodic maintenance and inspections, maintenance is performed only when malfunctions occur or when special testing changes are made.

The reporting of malfunctions and suspected malfunctions is processed through work load control and the appropriate personnel and shops are assigned to rectify the problem.

Since only one person was performing the field evaluation part of this study, only one task could be treated at a time. The method of selecting the task for this study depended on the following priorities:

- a. PSTE evaluation took priority over other testing for using this technique.
- b. The task should be associated with one of the two study subsystems.
- c. The work involving potentially critical tasks was evaluated in preference to those that have little likelihood of being crucial.
- d. An effort was made to develop systematic evaluation as the test progressed so that the ultimate result would be a thorough analysis.

These criteria did not preclude the use of this technique for other test sections. When time permitted, attempts were made to participate in the investigation of other test applications including; briefings and debriefings, instructions, communication, documentation, and subsystems in earlier phases of development.

In order to utilize the experience and knowledge of the test team, the investigator coordinated his efforts with the other sections prior to applying the technique.

The organization of the F-4E test team is shown in Figure 2. The detailed organization of the maintenance section is shown in Figure 3.

The maintenance data collection forms and reliability data provided information regarding frequency of failures and gross times for tasks. These data could provide extrapolation of task impact on large operational units, squadrons, and wings.

The location and time of occurrence of maintenance varied widely. Principal locations were flight line, hangar, shop, hot line, and gun butt range. The time that maintenance occurred could be anytime in any 24 hour period, depending on the criticality of the maintenance. Nighttime, flight line, hot line, and gun butt range presented the most difficult environments for

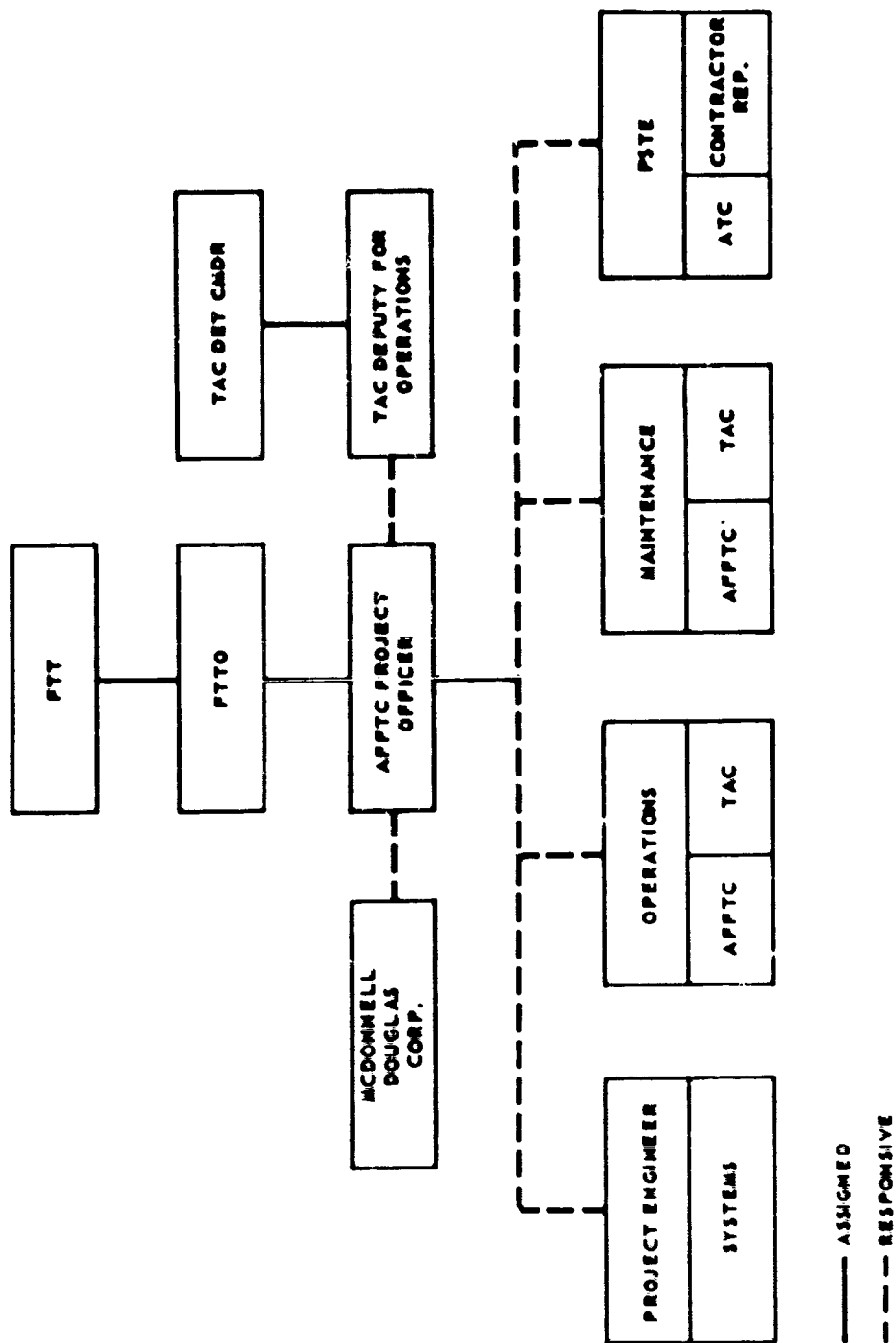


Figure 2 P-4E Category II Test Team Structure

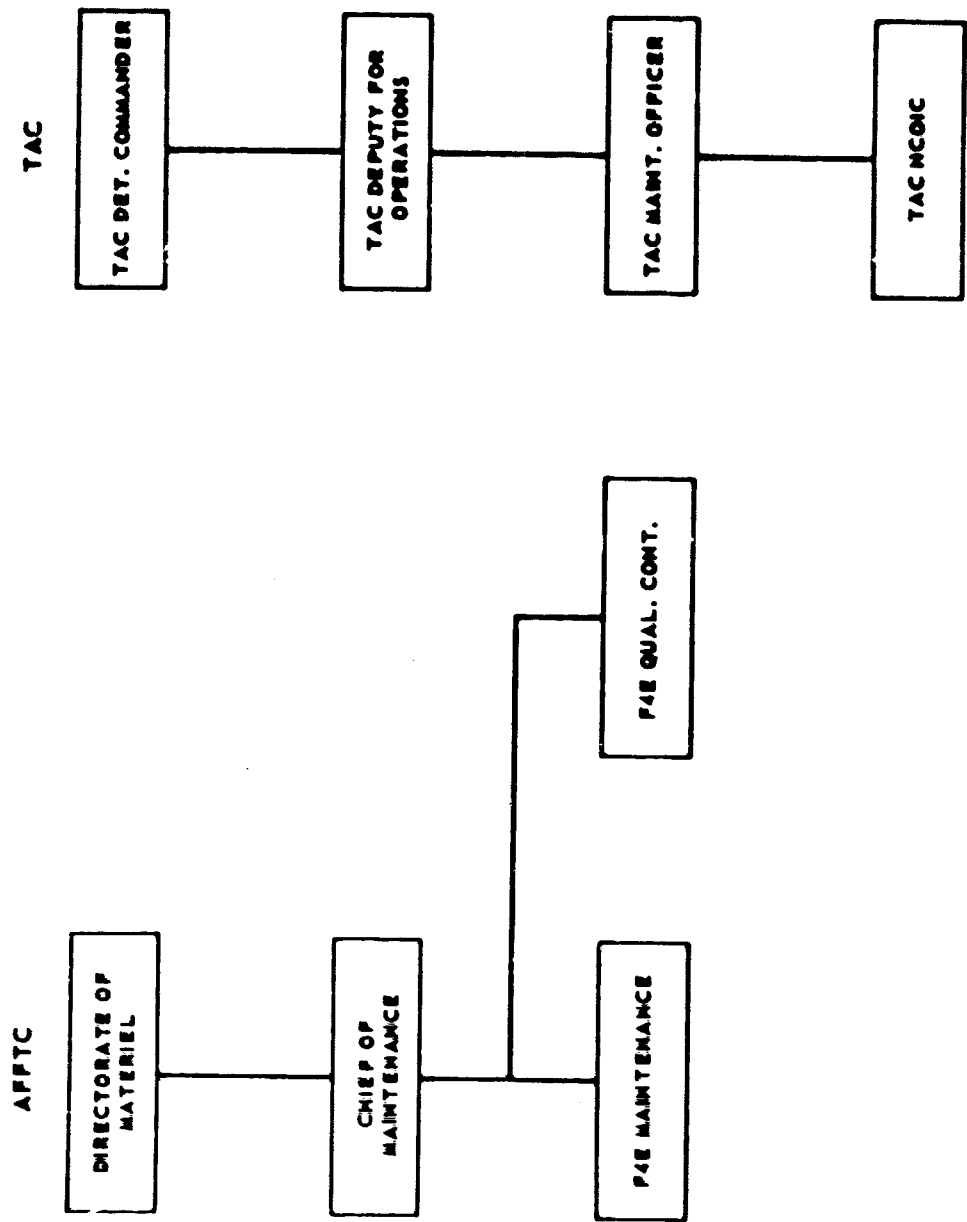


Figure 3. F-4E Category II Maintenance Structure

PSTE. However, the environmental effects upon the achievement of tasks has been a significant PSTE consideration.

The transportation of the video tape recording equipment from one hangar or shop to another could involve Air Force trucks or tractors. In the past there had not been any difficulty in obtaining transportation.

The results were to be in the form of magnetic tape recordings. The audio and video records on these tapes were to be played back through the video tape recorder and a TV monitor.

The evaluation of the data could have been either an individual or group effort. The decision as to what test sections were to be represented was dependent on the nature of the task and its problems. It was anticipated that the preliminary evaluation of the recording would lead to a recommended audience. The kind and amount of information that each section, or the entire test team could extract from the technique is one of the questions to be answered by this study. From the PSTE standpoint the following problems deserved special attention:

Human Error, and Design Leading to Human Error

Problems of this type should be fully documented. It is possible that by backtracking from the error and replaying the tape it would be possible to identify the condition(s) that created the error. These might have been in the design of the equipment, the procedure, tools, or an outgrowth of training or written or spoken orders.

Excessive Time

The expenditure of excessive time to accomplish what should be a simple task is often a product of design and procedure problems. This type of problem should be evaluated in terms of expected frequency of the task. Quality engineering offers a medium for obtaining effective changes.

Improper Diagnosis of Malfunction

Previously, this area has not been effectively evaluated. The identification as to what caused the incorrect identification of a malfunctioning item often requires detailed investigation. The causative factor(s) may be training, procedure, skill, and design. Early solution to this type of problem leads to greater system efficiency.

Ineffective Team Work

Analyses of task loading and time sharing, communication, and work space could result in an evaluation of group behavior.

T.O. Deficiencies

The problems associated with some tasks are the results of inadequate training of personnel or an unfortunate result of transfer of training.

The Air Training Command representatives should be active in resolution of problems of this nature.

Adequacy of Tools

Issued tools are sometimes inadequate. Their design and material may result in injury to personnel, damage to equipment, and improperly adjusted equipment. As the men become more acquainted with the equipment, they improvise special tools that frequently improve the maintenance. The documentation and dissemination of more effective tools should be expedited.

Other factors that could contribute to task ineffectiveness are fear, conflicting orders, individual inadequacy, and physical and mental condition. Environmental factors such as poor light, dust, heat, cold and rain could create problems not present under more favorable conditions.

PREPARATION FOR PERFORMING PSTX

In order to effectively use and evaluate any new technique or device for PSTX it is necessary for the person responsible for using the technique to be familiar with the type of task being performed. This does not necessarily mean that he must have precise knowledge of the task being evaluated. For example, nearly all the loadings of munitions follow a pattern in sequencing, tools, AGE, and involve the same number of people in the load crew. If one knew these generalities he could adequately record a procedure involving a new missile, bomb or pod hanging. Maintenance performed on electronics, hydraulics, airframe and other subsystems has general patterns that are characteristic to each subsystem.

a. Personnel.

It is desirable to have human factors personnel do the work, especially those who know the basic problem areas in weapon system maintenance. The knowledge of these personnel permits them to pinpoint areas where the critical tasks are likely to occur and predict when a close-up view will identify a problem. They also know what questions to ask the maintenance personnel, and how to isolate problems. Unfortunately, human factors personnel with maintenance experience are relatively rare.

It has been our experience that other personnel can be trained 'on site' to become effective PSTX team members. These people are usually given an orientation involving the PS effort in the weapon system, equipment description, and basic PSTX responsibilities and techniques. In the early phases of testing they are utilized to run down details and to observe specific tasks with specific instructions as to what to look for. Later, they observe and evaluate the maintenance activities with limited direction. The reports made by these personnel are reviewed by human factors personnel prior to submittal to the test force for inclusion in the Category test report.

b. Technical Order Review.

One of the most helpful steps is a review of the task to be evaluated from its description in the Technical Order. It may or may not be necessary to require help in the interpretation of the procedures. If help is required, there are several test sections that are normally available: maintenance personnel that are responsible for the task; engineering personnel (Air Force, contractor, or vendor); and training and product support personnel. The use of the Technical Orders as a guide to recording also aids in the determination of adherence to or departure from procedures, identification of T.O. error, and the improvement of these procedures.

c. Critical Task Data.

Throughout the development of a weapon system, the PS group has the responsibility of identifying critical tasks. Early evaluation of these tasks may indicate little or no problem. However, with a change of environment, personnel, frequency of use, or unexpected changes in manning, subsystem responsibility, or design, mistakes in performing critical tasks can have serious consequences. With the knowledge of these suspect areas, one can select the techniques with which to test for criticality.

d. PSTE Problem Reports.

The test force personnel are briefed as to what type of problems are to be reported to the PSTE team and investigated by the PSTE team. Frequently, the original report from the maintenance personnel is sketchy and misleading. The responsibility of the PSTE team is not only to document the source of the problem, but to recommend possible solutions to it.

e. Observation.

Frequently, it is advantageous to observe the task being performed before attempting recording. The specific area requiring data can be determined and the effort can be made more efficient.

f. Liaison With Test Sections.

It is not unusual to hear references to possible improvements by engineers, quality control, and maintainability personnel. Some of their thoughts regarding improvement may be veiled or embryonic. VTR does offer a good basis for comparing various approaches to problem solution or procedure improvement. During the course of this study two PSTE investigations were made upon information contained in a casual remarks by test personnel.

Some samples of the application of the video tape technique to the subsystems may serve to illustrate the possible products that might have been derived from the VTR technique.

- (1) A measure of time to remove the radar. How much time is being consumed in reading T.O.'s, disconnecting wire bundles, removing wave

guides, etc. The tape could have pinpointed a faulty procedure or tool slowing down a task segment.

- (2) A graphic presentation of the requirements for precision of ~~movement~~, visual or manual access, weight handling requirements, and other factors.
- (3) An indication of the adequacy of the T.O. in enabling the man to locate the proper hardware and perform the task.
- (4) A record of human error, and possibly an idea as to what led to the error.
- (5) The adequacy of the tools through use of the zoom lens. Did the tool engage the fastener properly? Did the tool run into structural interference upon insertion or rotation? Did the tool burr or de-face the fasteners or equipment? Was the proper tool available or was a makeshift tool being used?
- (6) Analysis of work space envelope by making the recording through a one-foot string grid.
- (7) Definition of restraints imposed on a maintenance team in respect to communication, visual access, environment (noise, illumination).

SECTION III

EQUIPMENT

GENERAL

The VTR equipment that was modified for this study had been used in the McDonnell Douglas Human Performance Laboratory prior to the beginning of this contract. This equipment had been used primarily in laboratory work involving ejection seat development, space reconnaissance, and human engineering evaluation of F-4 aircraft subsystems. Some of the primary advantages of using the VTR technique are:

- a. Full hour of uninterrupted recording.
- b. Quick playback of recording making it possible to assess results or prerecord substandard data.
- c. No processing is required.
- d. Relatively easy to operate and to assess.
- e. Reclaimable tape that can be used many times.

In addition, the video tape recording technique does not suffer from the following disadvantages of a movie camera system:

- a. Limited to 3-4 minutes of film before reloading.
- b. Provides limited feedback as to focus, exposure, and framing.
- c. Is difficult to achieve a good sound track, and requires film processing.

However, there are certain disadvantages of VTR that should be mentioned. Some of these disadvantages were reduced or negated in the development of the equipment for this study.

- a. The small helical scan video tape recorders have a limited resolution of 400 lines. Therefore, they are inferior to moving pictures in resolving fine detail. Wide angle and distant scenes give the impression of being slightly out of focus.
- b. Rendering of shading is limited to seven densities. In addition, the vidicon tube adjusts itself to overall light intensity. When a bright object is in a dark area the vidicon will sense the overall light falling upon it and will desensitize causing the darker areas to go nearly black, creating lack of detail in the shadow areas.

- c. The weight of the equipment available in the MDC Human Performance Laboratory is more than 250 pounds. It could not be picked up and rapidly moved about. A number of different brands of portable VTR equipment are commercially available, however.
- d. The power and signal cables were numerous and created awkward working conditions.
- e. Overhead camera positioning is limited because the vidicon tube face is subject to damage from filament debris falling on the vidicon face.
- f. The camera had no built-in monitor to provide the operator video feedback for camera control.

The video tape recording equipment available at the start of the study is listed below:

Video Tape Recorder, Ampex Model VR 7000
 Camera, General Precision Laboratory, 700
 Zoom Lens, Canon 25-100mm, f 1.8, Model TV-16
 Zoom Lens, Angenieux, 15-150mm, F 2.8
 Pizar Lens, Kern-Paillard 25mm, f 1.5
 Monitor, Miratel Model LV8M, 5" x 7" Screen
 Tripod, Sampson, Model 7301
 Tripod Dolly, Sampson, Model 7601
 Lights and Accessories
 Conrac 25" Monitor, Model CVA 23

In addition to the above equipment, the Bell and Howell Company loaned a Model 2920 Portable Tape Recorder for the field verification of the technique.

The technical specifications of this equipment are listed in Appendix III and the approximate costs for the items are listed in Appendix IV.

Development of this off-the-shelf equipment into a system capable of performing under field conditions involved the following:

- a. Integration of the elements in an easily used system through modification of additions.

- b. Modifications to improve the transportability of the equipment and to provide for rapid assembly and disassembly.
- c. Provisions for the security of the equipment and for its protection against damage.

EQUIPMENT ELEMENTS

a. Orientation.

The video tape recording system is composed of two primary units, the camera station and the video tape recorder cart station. (See Figure 4). In the interest of clarity, the equipment will be described separately for each station and the sequence of description will be based primarily upon the path of the video and audio signals from the lens of the camera and microphones to the TV image on the monitor and the sound from the speaker or headset.

Items will be described in terms of their off-the-shelf characteristics and the need for modification. Secondly, modifications to the items will be described with the rationale for changes or additions. Drawings and construction details will be found in Appendix II. The field assessment of the equipment and the modifications will be presented in Section V.

b. Lenses.

A wide variety of fixed focal length lenses were available for this study. However, preliminary work with the system indicated that zoom type lenses had some basic advantages. A zoom lens allows the operator to vary the focal length. This feature allows the operator to frame the object and to select the image size without having to change the camera position. Frequently, the long focal length position (telephoto) allows the operator to see on the monitor screen detail that he cannot see with the naked eye. By using a short focal length position (wide angle) to start the scene, the evaluator can be orientated as to the location of a particular unit with respect to the aircraft or primary piece of equipment. During the task recording an occasional return to wide angle aids in reorientating the evaluator. The focus of zoom lenses is accomplished by zooming in on the area to be recorded and adjusting the focus ring until the image is sharp on the monitor screen. On subsequent zooming out (reducing focal length) the lens will maintain focus through the range of focal lengths.

Fixed focal length lenses can be used on the video cameras. The cameras can be equipped with a turret containing several fixed focal length lenses. However, the selection and adjustment of the lenses under a continuing scene results in interruptions and momentary poor picture quality while focusing and framing. The cost of the zoom lenses is given in Appendix IV.



Figure 4. Video Tape Recording System being Transported on Flight Line

The following lenses were selected and used during the field phase of this study.

(1) Angenieux Zoom Lens.

This lens has a 15 to 150 mm focal length range, and a speed of $f/2.8$. It is equipped with a 16mm C-mount thread and can be used on most TV and 16mm movie cameras. The adjustments for focus, zoom (focal length), and iris are all made manually. The focus and iris adjustments are made by rotation of the appropriate rings. The zoom adjustment is made by using a crank that engages a gear on the zoom ring. This lens will focus as close as 5' from the object. The cone of acceptance varies from $45^{\circ}32'$ at 15mm to $4^{\circ}48'$ at 150mm. Figure 5 depicts the range of coverage at 10' from the camera position.

No modifications were made to this lens for the field work.

(2) Canon Zoom Lens.

The Canon Zoom Lens has a 25 to 100mm focal length range and a speed of $f/1.8$. It also has a C-mount. All adjustments are made by means of rings. This lens will focus as close as 8' from the object. The cone of acceptance ranges from approximately $28^{\circ}30'$ at 25mm to $7^{\circ}07'$ at 100mm.

The Canon Lens, although much faster (better under poor light conditions), is much more limited in varying the field of view.

No modifications were made to this lens.

c. Video Camera.

The video camera used in this study was a General Precision Laboratory, Precision 700 Television Camera. The technical specifications are listed in Appendix III.

General information that is pertinent to this study is as follows:

Weight	12 lbs.
Size	6.56" high, 4.5" wide, 13.5" long
Controls	Off-On, beam, target, and focus
Mounting	Bottom tapped 1/4" x 20 thread
Power Requirements	100-130 volts AC, 50-60 Hz single phase, 40 watts (max)

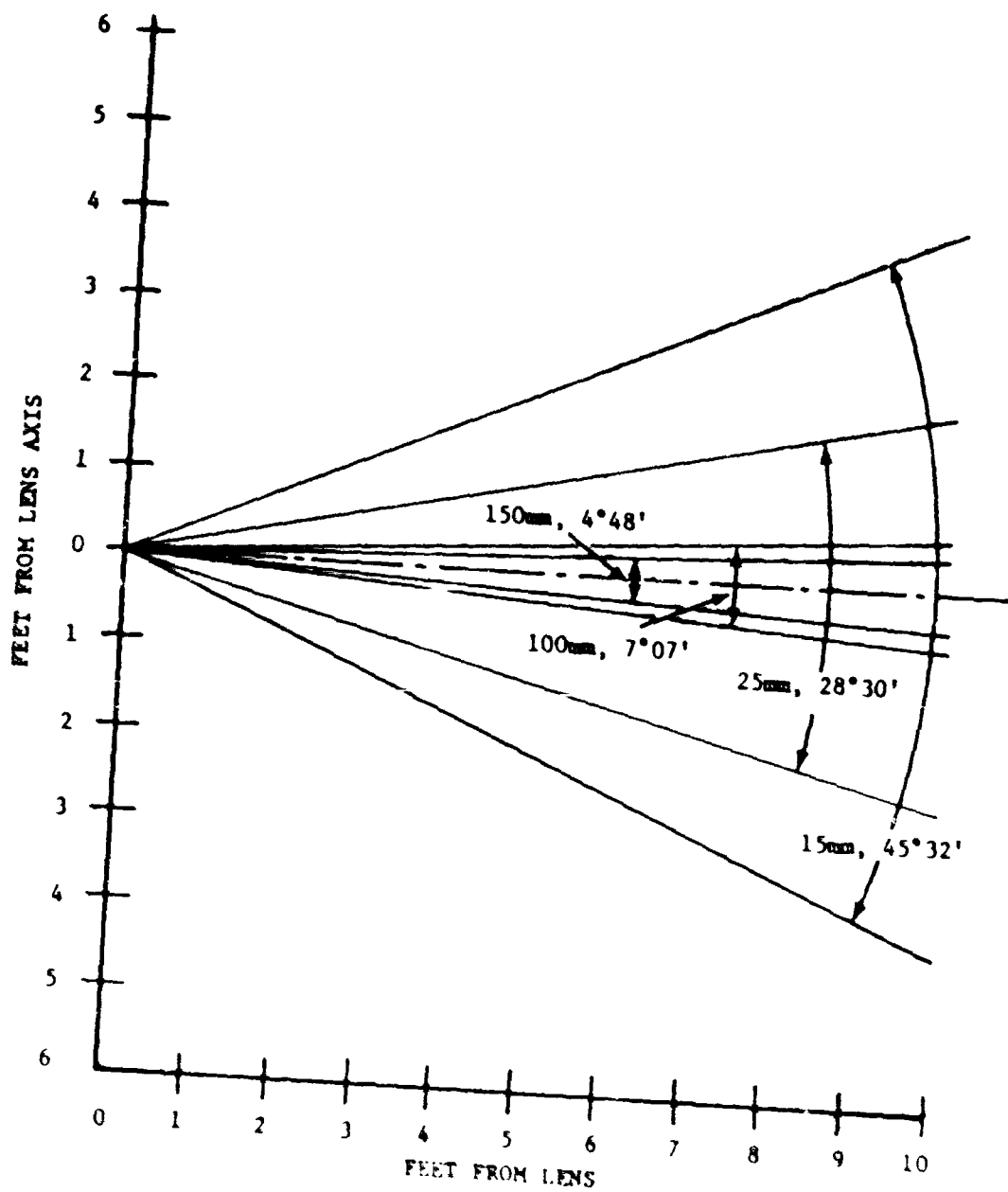


Figure 5. Lens Coverage at Various Focal Lengths

Scanning Standards 525 lines/frame, random interlace
 30 frames/second, 60 fields/second

Lens Mount Standard 16mm "C" mount

This camera is entirely solid state except for the vidicon tube and indicator lamp. No external or remote controls are necessary for adjustment or operation.

During the preliminary phase of this study it was determined that this camera was adequate. Its advantages included light weight, good resolution, and completely self contained.

There was a problem in not having a feedback on the proper adjustment of the beam and target controls. Ideally, the video signal should be 1 volt going into the video tape recorder. Any more or less will detract from the amount of information being recorded. The beam and target controls determine the signal strength but there was no way of knowing precisely where to position them. We were informed that a relatively simple electronic circuit and meter would provide a reading for the video signal value. The schematic and parts list are shown in Appendix II. Basically, a sampling of the video signal is rectified to direct current and the circuit is adjusted so as to give a reading of 1 volt when the signal is one volt.

This small meter and its electronics were installed on the back of the camera below the controls (See Figure 6). The method of setting the controls is described in Appendix I.

The second problem associated with the camera was the method of mounting it to the tripod. The single 1/4" x 20 bolt provisions does not assure a tight mount, and with the 12 lb. camera and 3 lb. lens there was a chance of breaking the bolt.

A "V" bed camera mount was designed to be attached to the tripod head, and an inverted "V" plate was built to be installed permanently on the bottom of the camera with screws (See Figure 7). The camera and camera plate are aligned with the tripod camera mount and pushed until there is a complete engagement. A locking dog on the camera mount is rotated to tighten the mount against the camera plate. This modification permits fast and positive camera installation. No further modifications were made to the camera.

d. Cabling and Connectors.

Early attempts to wire up the system made it obvious that the number of cables, and their storage and placement requirements would necessitate a major change. The camera station alone had eight separate signal or power cables running to and from it. In addition, the length of the cables varied widely, resulting in shortages and excess. Figure 3-4 in Appendix I indicates two cabling diagrams required for recording in the field.



Figure 6. Video Level Meter Mounted on Back of GPL 700 Camera



Figure 7. "V" Dad Mount and Inverted "V" Plate on Bottom of Camera

Sketches and mockups were made to establish a configuration that would permit the camera station to be moved up to sixty feet in any direction from the video tape recorder cart. Although there are six signal cables between the two, five are enclosed in a single vinyl sleeve and attached at a common point (distribution box) on the tripod (see Figure 8).

The camera station is supplied with power by means of a #14 extension cord sixty feet long. The system power distribution box with a one foot cable and locking plug attaches to the distal end of the power cable. This box is provided with a cleat that engages one of the mounting blocks on the tripod (see Figure 9). With these wiring modifications and combinations the number of separate cables was reduced to two making stowage and maneuvering much easier.

Originally all of the coaxial connectors were of the threaded screw type that required numerous turns to engage the cables with their connectors. Several times malfunctions were traced to loose connectors. All of the cables were changed to BNC type connectors that require a bayonet-lock coupling that provided a quick and positive locking. The camera, monitor, and other equipment that had the screw-on type connectors were provided with adapters to receive the BNC cable connectors.

e. Tripod and Dolly.

The weight of the camera and the need for keeping the camera on the task necessitated the use of a tripod. In addition, the tripod itself required mobility, and this was provided by means of a dolly. The tripod was a Sampson, Model 7301 which had a vertical range of 32" to 72" and weighed 10 pounds. The tripod was equipped with a Sampson, Model 7201 pan/tilt head which allowed 360° rotation and adjustments 45° up, 90° down.

The camera mount is attached to the pan/tilt head by means of two Phillips-head screws. Two pins aid in maintaining the alignment and rigidity of the mounting. Modifications to the head involved the drilling and tapping of holes for the mount screws and the drilling of holes for the mount alignment pins. The 1/4" x 20 mount screw was not removed and is available for the conventional mounting of photographic camera or television cameras.

Additions to the tripod include two mounting blocks for the video/audio junction box and the system power junction box and a remote control unit. The mounting blocks are hinged blocks that are clamped on the tripod legs by means of Allen head cap screws (see Figure 9).

f. Video/Audio Junction Box.

The Video/Audio junction box was designed to provide for several functions. It provides a common point of attachment for the video, audio, and remote control lines interconnecting with the video tape recorder and it also provides the redistribution of signal lines to the camera, monitor, remote control unit, microphones, and headset. The junction box also allows the operator to select



Figure 8. Five Signal Cables in Vinyl Sleeve Connect to Video/Audio Junction Box



Figure 9. System Power Distribution Box, Video/Audio Junction Box, and One of the Mounting Blocks to which they are attached

audio input from one of the three microphones (only one can be recorded at a time), and gives the operator the capability of selecting live video (direct from camera to monitor), or VTR video/audio (image after going through VTR electronics). The video/audio junction box is mounted on the tripod by means of a wedge. See Figure 10 through 12.

g. System Power Junction Box.

The camera and monitor both require 115V 60 H_z power. A wedge, similar to that on the back of the video/audio junction box, was affixed to the back of a four outlet junction box (Figure 9). A two foot length length of #14 cable was wired to the four outlets. The distal end of this cord was provided with a three prong, locking, male connector. This connector mates with the power cable from the video tape recorder cart.

h. Remote Control Unit.

In order to provide for remote operation of the VTR a small switch box was designed to fit on the pan/tilt head handle (Figure 13). The original remote control unit had three push button switches but no signal lights. In the early testing of the VTR equipment several scenes were missed because the operator was unaware that the record "R" switch had not been activated. A later version incorporated indicator lights, red for 'record' and white for 'play'. The red switch guard and red light for 'record' remind the operator that he might erase previously recorded data.

The VTK can be operated with or without the remote control unit.

i. Monitor

The monitor is a Miratel, Model LV8M, and produces an image approximately 5" high x 7" wide. It is one of the older types using tubes instead of solid state devices. Consequently, it is a relatively heavy unit weighing 33 lbs.

The monitor serves two functions: (1) Gives the operator video feedback for framing, focus, and exposure. The monitor is essential to the camera/operator station. The controls on the monitor allow for electronic adjustment of focus, contrast, brightness, and for horizontal and vertical adjustments. In the modified VTR system the video signal can be displayed directly from the camera, as with TV, or routed through the video tape recorder, to confirm most of the recorder electronics. (2) Provides a display during playback of the recording. Playback may be used immediately after recording to verify that the content and quality are what the operator wanted. Also, the playback may be used to assess a particular part of the task. Later, the playback may be used for detailed analysis, usually in a more quiet environment.

Although the MDC Human Performance Laboratory had a 23" Conrac monitor, its size and weight made it impractical for field operations. The 5" x 7" image of the Miratel was adequate for both recording and data assessment.



Figure 10. Top View of Video/Audio Junction Box

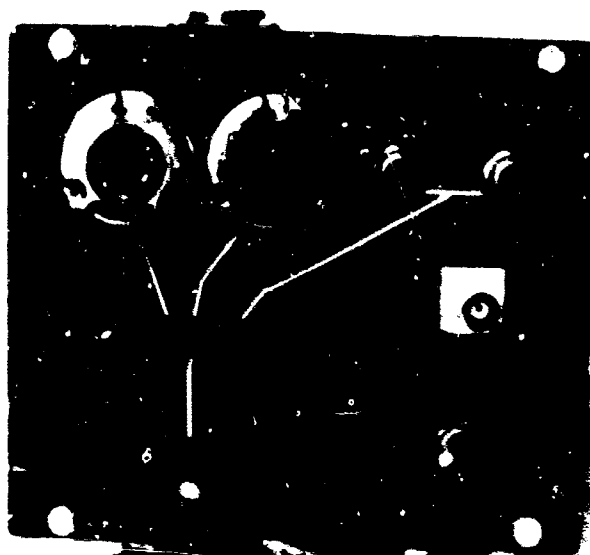


Figure 11. Front View of Video/Audio Junction Box

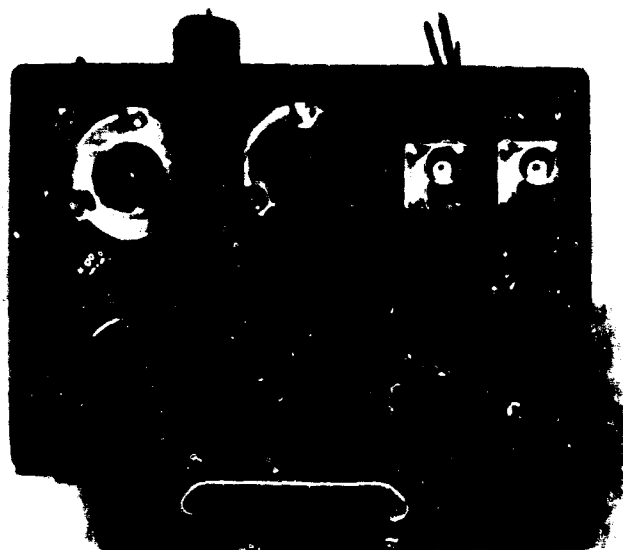


Figure 12. Bottom View of Video/Audio Junction Box

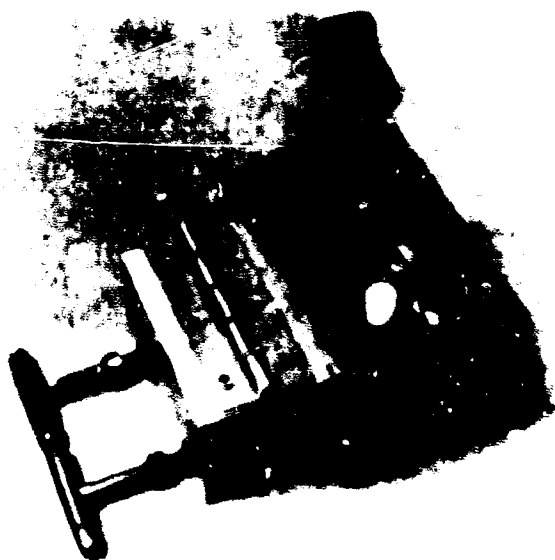


Figure 13. Remote Control Unit

Only one addition was made to the monitor. This was a sheet metal glare shield to reduce ambient light falling on the phosphor surface of the picture tube. This addition is essential for outdoor recording.

A monitor mounting bracket was added to the dolly. The bracket held the monitor at an angle to provide for video feedback to the operator, and also maintained the mobility of the camera station (Figures 14 and 15). The bracket is mounted to the dolly by means of "U" bolts and is easily attached. A jury strut provides for adjusting the monitor angle up to 90°.

j. Video Tape Recorders.

Two video tape recorders were used in this study, an Ampex, Model 7000, and a Bell and Howell, Model 2920 recorder. The detailed specifications for them are in Appendix III. Each will be discussed separately.

The Ampex Model 7000 recorder was part of the MDC Human Performance Laboratory equipment. The modifications to this system were designed around this recorder. Some of the basic characteristics are listed below.

Resolution	350 lines
Uninterrupted recording time	1 hour
Tape capacity	3000 feet
Tape size & material	1", 1 mil Mylar base
Tape speed	9.6 inches/second
Rewind speed (3000' of tape)	4 minutes
Fast forward (3000' of tape)	14 minutes
Audio channel	one
Power requirements	105 - 125 volts, 60 H _z , 310 watts maximum
Size	29" ^w x 18" ^h x 15" ^d
Weight	80 lbs.
Operating position	Horizontal only

This recorder also has an internal 6 watt amplifier for audio playback, and a modulator output that will permit video playback over standard television sets. Off-the-air programs may also be recorded by using the RF output of the television receiver and running it into the "video-in" connector.



Figure 14. TV Monitor Mounting Bracket Attached to Dolly Spreaders



Figure 15. Monitor Installed in Mounting Bracket

The controls on this recorder provide for the following functions:

Audio level adjustment

Video level adjustment

Selection of audio input

Audio volume control

Tracking (playback only)

Record, play, and stop (can be remotely controlled)

Rewind, stop, forward (manual)

Ready, thread (manual)

Power (off, on)

Tension control

Displays in addition to the video picture on the monitor consist of audio level meter, video level meter, and the counter.

This recorder is relatively easy to operate. An hour or two of instruction is adequate for simple recording and playback operations. Complete hook-up and operating instructions are presented in Appendix I.

This recorder provides for both recording and playback functions. Advantages of the device are the capability of recording hour long scenes with audio annotation, quick playback capability, and ease of operation.

Disadvantages experienced with this recorder consisted of the following items:

- (1) The weight and size of this equipment, 80 lbs., 29"^w x 18"^h x 15"^d, precluded hand carrying it from one location to another. The video tape recorder cart was built to counteract this disadvantage.
- (2) The tasks involved with running the recorder required the operator to constantly move between the camera and the recorder to position the RECORD, PLAY, STOP, REWIND, and FORWARD controls. This problem was partially solved by fabrication of a remote control box to provide remote record and stop, or play and stop functions.
- (3) The counter displays a number which corresponds to the number of revolutions that the take-up reel makes. The numbers are used to locate scenes on the tape. However, this counter does not relate

directly to time. A chart which relates counter readings to time was made to counteract this deficiency (See Appendix I).

- (4) The speed of the "fast forward" mode is too slow for search and acquisition of data. Total time is fourteen minutes from start to end.
- (5) With only one audio channel one cannot preserve the original sound track and add commentary or voice annotation. Other Ampex machines have two voice channels.

The only modification made directly to the recorder was an Ampex modification that allowed it to stay in the "ready" position of "stop" without wearing the oxide from the tape and clogging the video head.

The Bell and Howell Model 2920 recorder is capable of both black and white and color recording. The color capability was not used during this study. This recorder was loaned to the author for use on this study. It provided a comparison of recorders and permitted the reproduction and editing of tapes. Some of the basic characteristics are as follow:

Resolution	400 lines
Uninterrupted recording time	1 hour
Tape capacity	2150 feet
Tape size & material	1", 1 mil mylar base
Tape speed	6.91 inches/second
Rewind speed (2150' of tape)	90 seconds
Fast forward (2150' of tape)	90 seconds
Audio channels	Two
Power requirements	110-130 volts, 60 H _z , 300 watts maximum
Size	23 5/8" w, 13 1/2" h, 11 3/8" d
Weight	65 pounds
Operating position	Vertical or horizontal

The controls on this recorder provide for the following functions:

Audio level adjustment (both channels)

Video level adjustment

Selection of audio input (either channel or both)

Audio volume control

Tracking control

Rewind, forward, play, stop, record (can be remotely controlled)

Power (off, on)

Tension control

Stop motion switch

Displays in addition to the video picture on the monitor consist of audio level meter (either channel), video level meter, and a timer.

The offer to provide the Bell and Howell recorder for use during the field phase of this study came relatively late - after the system had been integrated with the Ampex recorder. However, most of the modifications and system additions would be comparable with either recorder. The connections and hook-up were similar. The only major problem was in the provision for a remote control box.

The Bell & Howell unit had several distinct advantages:

- (1) It was much smaller. It occupied only 60% of the area of the Ampex and weighed 15 pounds less.
- (2) All of the tape movement and record/play functions were operable with pushbuttons, and could have been remotely controlled.
- (3) The tape counter was in units of minutes and tenths of minutes, allowing the operator to estimate quantity remaining or expended.
- (4) The ninety second end-to-end wind and rewind rate was a definite advantage in editing and data retrieval.
- (5) The cost of tape was significantly lower.
- (6) The resolution was higher than the Ampex.
- (7) The two audio channels allowed for audio annotation to the original sound track.

Disadvantages consisted of the following:

- (1) The recorder had no audio amplifier or speaker and the only way to monitor the sound was with earphones. This problem was partially solved by the procurement of a small audio amplifier and speaker that plugged into the "audio-out" connector.
- (2) This particular unit had the connectors on the bottom making it difficult to hook up.
- (3) A standard TV set cannot be used as a monitor because the recorder does not have a modulated signal output.

No modifications other than the addition of the audio amplifier and speaker were made.

It is not within the scope of this report to explain the principles and theory of a video tape recorder. Descriptions may be found in Reference 1, 2, and 3. One important characteristic of video taping must be kept in mind however: synchronization is dependent on a control track, an invisible timing pulse that determines picture stability. Variation in tape speed and in the frequency of the power supply seriously affect recording and playback. The synchronization pulses are analogous to the sprocket holes in a movie film.

Although there are 525 lines on the television screen this should not be interpreted as the resolution of the camera or video tape recorder. The represent the upper limit of vertical resolution however.

Horizontal resolution is the number of vertical lines that can be seen in three quarters of the width of the picture. A 350 line resolution is that which will resolve 350 vertical lines over the width of the picture; the three quarters limitation takes into account the poorer resolution near the edges. Therefore, the true resolution of the system will not vary with the size of the monitor. A small screen may have an apparent higher resolution than a large screen viewed from a short distance, but the amount of information on both is the same.

The tape is similar to that used in magnetic audio recorders and is supplied on 9 3/4 inch reels holding 3000 feet. The sensitivity of this tape to X-rays, magnetism, dirt, and heat requires reasonable care in use and storage.

k. Video Tape Recorder Cart.

Some means of combining the entire system into a single composite vehicle would be necessary to make the VTR system fieldworthy. This vehicle would also have to serve as a means of transportation and storage. Also, the features of such a vehicle should aid in the rapid assembly and hooking up of the system. An examination of test facilities revealed that the doorways and aisles would be as narrow as 31" and that the 90° turns in the passageways

would restrict the length of such a vehicle. The system would also have to have the capability of being used anywhere maintenance was being performed. Therefore, it would require features that allowed towing by tractors or trucks, and it would have to negotiate taxi-way and flight line obstructions such as cables, grates, and ramps. Provisions for locking up the items that were expensive or subject to breakage were also deemed necessary.

The basis for the vehicle was a standard wheeled office supply cart (see Figure 16). This cart was originally acquired to move the video tape recorder about the Human Engineering Laboratory. The four-inch independently pivoted wheels would hardly negotiate an obstacle as big as a pencil. The size of the cart proved to be adequate and would pass through 31" doors. A series of modifications made to the basic cabinet (See Figure 17) are briefly described below. Details of construction are shown in Appendix II.

The basic structure of the cart was strengthened to provide for the additional weight and the reconfigured wheel arrangement.

A tricycle wheel arrangement appeared to be the best design. A steerable front wheel would permit short radius turning without extending the length of the cart to an unacceptable degree. Placement of the cabinet over the larger pneumatic wheels was undesirable because this would raise the center of gravity too high and thereby make the cart unstable. The wheels were mounted so as to accept the cabinet between them. The 8-inch diameter wheels had 2.80/2.50-4 pneumatic tires mounted on them. These wheels had ball bearings which greatly reduced the friction.

In order to mount these wheels on the cart it was necessary to reinforce each end with 1/4" aluminum plate. This same reinforcement aided in the mounting of other cart equipment.

The two rear wheels required no modification and were merely bolted to the rear plate. These wheels were not pivoted. The front wheel had to be modified to provide for steering. The major modification was the making of a front fork so that the front wheel would clear the cart structure and provide for 360° movement. The front wheel unit required an extension of its pivot point so that a hinged tongue could be mounted to it to provide for steering and towing (see Figure 18).

The tongue is provided with an "O" ring so that Air Force tractors or trucks equipped with a pintle can be used to move the cart over long distances.

Most Air Force carts have an "O" ring on the tongue and a pintle on the back so that carts can be formed in a train. However, it was thought that providing a pintle on the VTR cart might result in its being overstressed if it were the link between a tractor and a heavy piece of AGE.

The pneumatic tires were a great improvement over the hard 2 7/8 inch diameter original wheels. This configuration should meet most of the requirements for field operation.

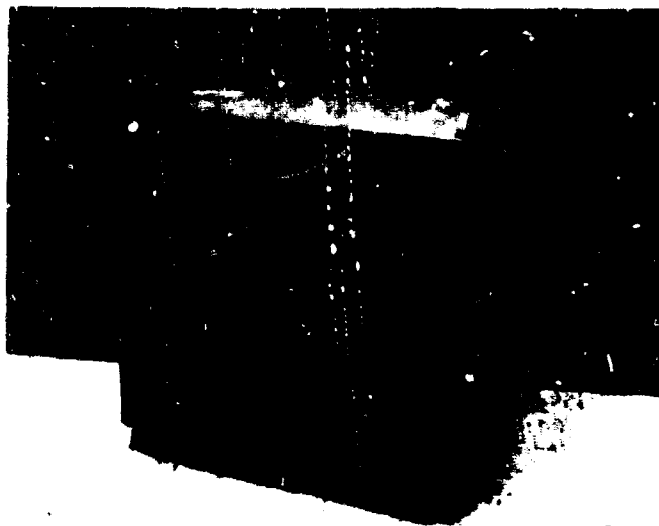


Figure 16. Office Supply Cart Used as a Basis for a VTR Cart

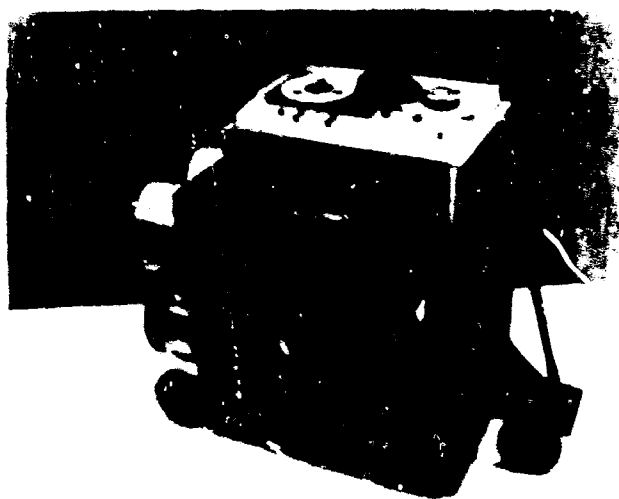


Figure 17. VTR Cart Modified for Field Application



Figure 18. VTR Cart Front Showing Tongue, Bolster, Wheel, and Voltage Control



Figure 19. VTR Cart Rear Showing Cable Reels and Rear Wheels

Originally there was no plan for voltage regulation. However, after experiencing difficulty with the line voltage fluctuation - one time as low as 90 volts - we decided to provide a voltage adjustment. A 20 ampere variable transformer was mounted to the heavy front plate. A voltmeter was mounted above the transformer control knob to provide for feedback on voltage. A recessed male receptacle was mounted on the side of the cart to receive wall power. The circuit included a variable transformer and a power distribution panel. The cart had four female connectors each supplying regulated voltage.

The assessment of potential test facilities indicated that availability of ground power would be a serious problem. Flight line and hangar work would require a minimum of 100 feet of power cord.

The camera station was designed to allow operation of the recorder without requiring the operator to walk back to the recorder during taping. In order to provide for camera mobility, the power lines between the camera station and the video tape recording cart were made 60 feet long.

One of the restrictions on the length of signal and power lines was the capacity of reels for cable stowage. Hand coiling of cabling was found to be extremely impractical and such coils wasted a great deal of stowage space. Several racks and reels were considered. The configuration adopted for the cart consisted of taking commercial wire reels and modifying them in the following manner: the hub was reinforced to take the weight and stress of reeling and unreeling. Holes were cut in the large hubs to provide stowage of the large connectors. Each was equipped with a folding handle and a locking device. The four reels were mounted on solid steel axles that protruded from the back of the cart. The cables were held on the reels by split aluminum retaining bands of aluminum alloy (see Figure 19).

The cables that are stowed on these reels are:

- (1) Two 108 feet #14 gauge 3-wire power cables allowing for 216 feet distance from power outlet or 108 feet for the VTR system and 108 feet for the lights.
- (2) One 60 feet, 5-cable complex in a vinyl sleeve that provides for video and audio signals (input and output), and remote control that allows the camera operator station to work 60 feet from the cart.
- (3) One 60 feet #14 gauge power cable that provides regulated power between the cart and the camera/operator station.

The internal arrangement of the original office supply cart was redesigned to provide stowage and security for the system equipment. The areas providing space for the more delicate equipment (camera, lenses, monitor, lights, and microphones) was padded with plastic foam to absorb shock during transportation. The camera cell was equipped with additional shock mounts to assure protection for the delicate vidicon tube. The video tape stowage provisions followed the recommended vertical position. Figure 20 depicts all of the cart equipment and cables in place.

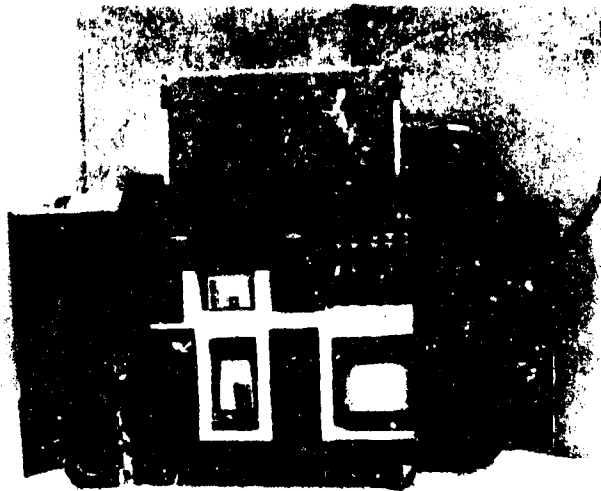


Figure 20. Interior of VTR Cart with all Equipment Stowed



Figure 21. Contents of VTR Cart

With the exception of the tripod, dolly, and TV monitor mounting bracket, the entire VTR system is stowed on or in the VTR cart. Although a display of all the equipment seems startling (Figure 21), it should be remembered that the system is usually assembled as shown in Figure 22. It takes less than 5 minutes to connect all cables, including wall power, and to prepare for recording. The four long cables are normally stowed on the reels and the equipment on the right panel is stowed in the drawer.

A complete inventory of parts, assembly and operating instructions and diagrams is in Appendix I. Construction details are in Appendix II.

1. Lights and Light Stands.

The need for adequate illumination was demonstrated in the early recording attempts. Although recordings can be made in relatively low light (6 to 12 footcandles) the images produced on the monitor are flat with a decided lack of contrast and overall clarity. Also, when the camera beam and target controls are set to compensate for the low light levels, the brighter portions of the image will persist. Then when the camera is zoomed or panned the bright areas will smear or appear as multiple images. Under these high gain conditions electrical interference becomes more prevalent. A number of commercial lamps were tried in conventional sockets and pivoting sockets. Most of these lamps had integral reflectors. It was determined that the light output and the uniformity and area of coverage would not be adequate for the test site.

A variety of lighting fixtures, lamps, tripods, and accessories was chosen from a professional lighting equipment manufacturer. This equipment consisted of the following items:

- 2 Vari-Beam 1000 Fixtures with lamps, Model LQV-10
- 2 Multi-Broad, Variable Focus with lamps, Model LQBM-10F
- 2 Light Stands on Coasters, Model SSBLHA
- 4 Diffusion Holders
- 2 4 Leaf Barn Doors
- 2 Pole Kings & Accessories
- 2 Gaffer Grips
- 2 Carrying Cases

Since most human factors personnel are not familiar with this type of lighting equipment, the items will be described.

The Vari-Beam 1000's with quartz iodine lamps are high intensity lighting units (1000 watts) that are capable of variable coverage from spot to flood

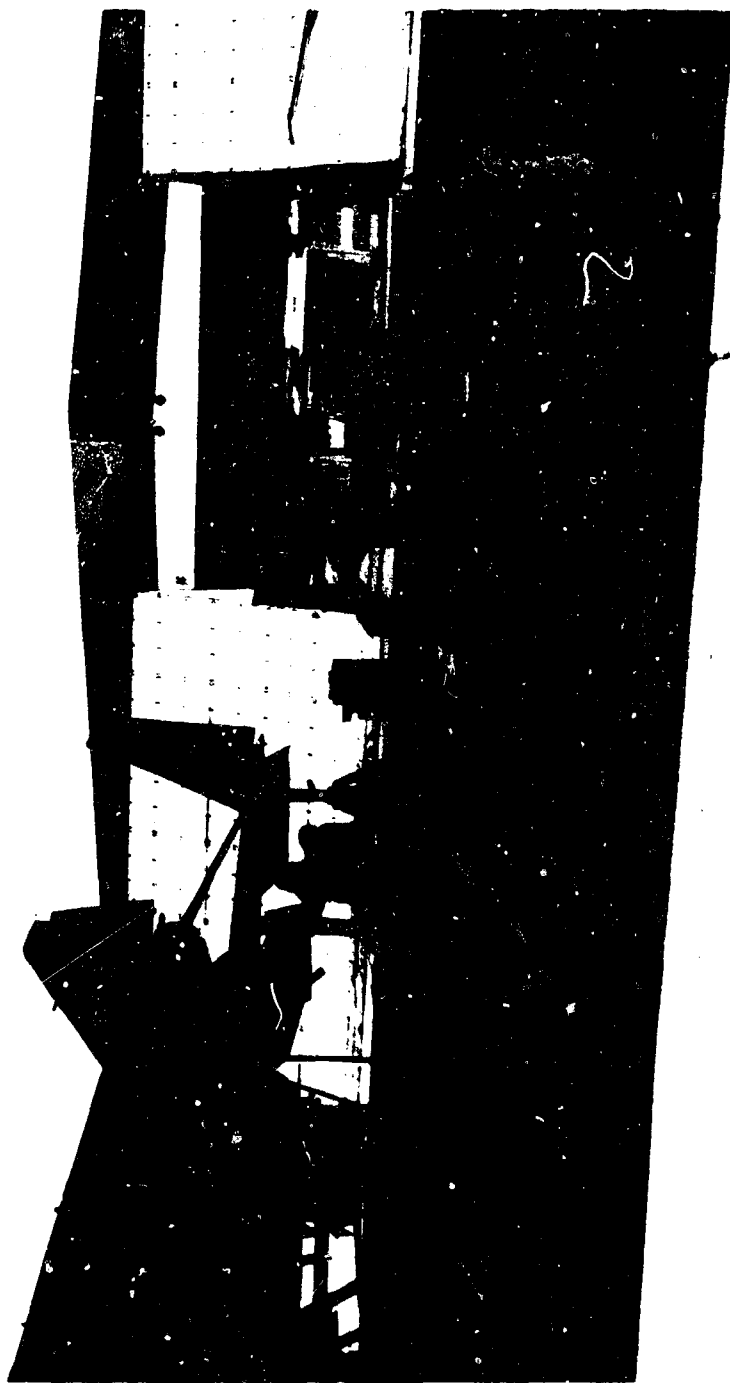


Figure 22. VTR Equipment Being Used on the Flight Line

lighting. The Multi-Broads also have the variable spot/flood capability and use 1000 watt lamps. The external characteristics of these light units are shown in Figures 23 through 26. The Vari-Beams are generally used on specific areas and to highlight points of interest. The Multi-Broads are used to fill in the shadows. The performance curves of the Vari-Beam and Multi-Broads are shown in Figure 27. Both of these lighting units will accept barn doors (variable panels that are used to shield the light), diffusion and filter holders. The tripods used with these lights extend to 114". See Figure 28.

The lighting fixtures can be mounted in a variety of ways. The primary means of mounting is the tripod (see Figure 28). Pipe and pole mountings are also frequently used. The Pole Kings are metal pipes that can be fitted together to build up a pole that can be inserted between the ceiling and floor. These poles afford a strong support for lights and are used in areas where tripods would not fit. See Figure 29. Two poles with a cross bar can be used for overhead illumination.



Figure 23. Vari-Beam 1000, Front View, Showing Lamp and Tripod Adjustments



Figure 24. Vari-Beam 1000, Rear View, Showing Spot/Field Adjustment and Power Switch

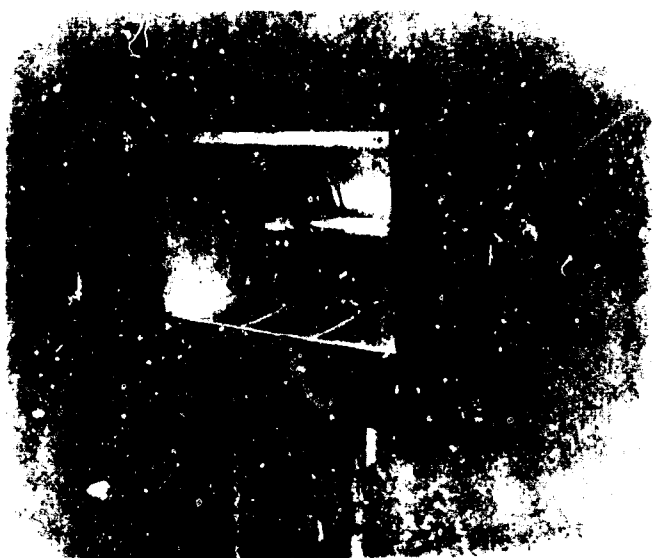


Figure 25. Multi-Broad Light, Front View, Showing Lamp and Provisions for Diffusion Screens and/or Filters

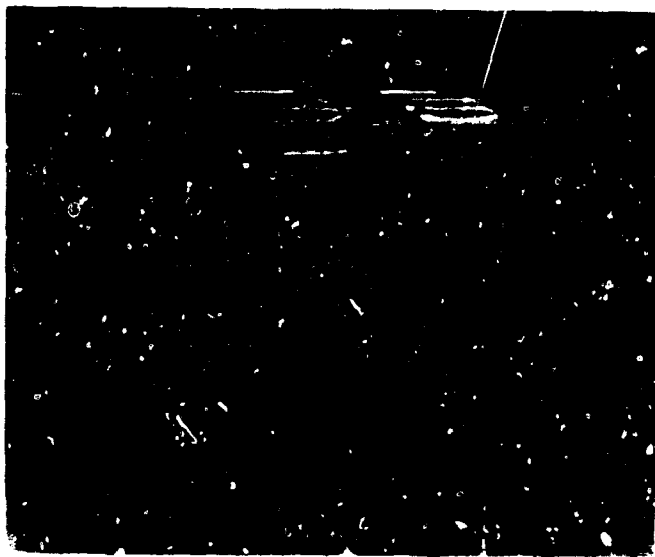
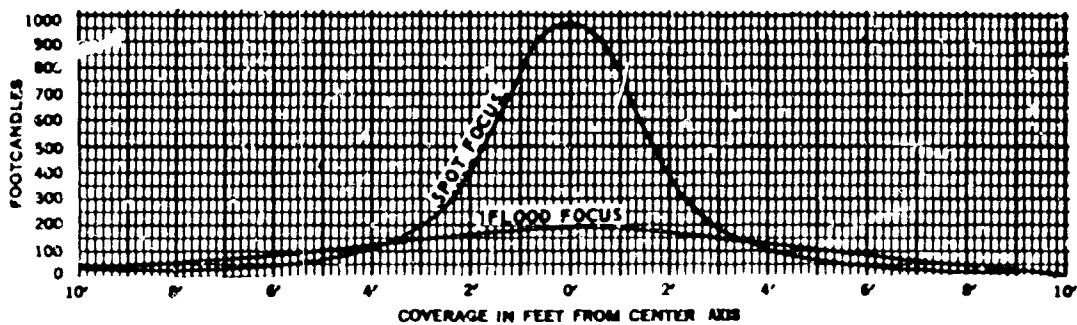


Figure 26. Multi-Broad Light Rear View, Showing Switch and Spot/Flood Adjustment Knob

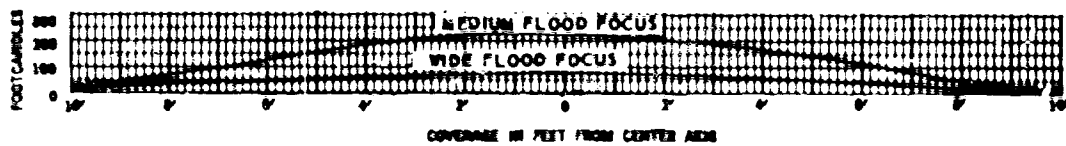
PERFORMANCE OF VARI-BEAM "1000" (LQV-10 AND LQV-10/TV)



Using ColorTran 1000-watt, 3200°K, 150-hour, BS10-32/1 (single-ended) Tungsten-Halogen "Quartz" clear lamp at 120 volts, consuming 8.3 amps.

FOCUSING RANGE	LAMP CODE	MAX. INTENSITY Footcandles at 10 feet	COVERAGE (at 10 ft.)		CANDLE-POWER	COVERAGE (Degrees)		LUMEN OUTPUT	
			1/2 Max.	1/10 Max.		1/2 Max.	1/10 Max.	1/2 Max.	1/10 Max.
Spot	BS10-32/1	948 FC	3.3' Dia.	7.8' Dia.	98,500	19° Dia.	43° Dia.	5,620	13,289
Flood	BS10-32/1	151 FC	11.3' x 8.4'	18.6' x 16.5'	16,400	59° x 46°	86° x 79°	8,267	14,663

PERFORMANCE OF ColorTran BROADS; Model LQBM-10F



MODEL	FOCUS POSITION	MAX. INT. Footcandles at 10 Feet (using BS-32 Lamp)	COVERAGE (at 10 Feet)		CANDLE-POWER (using BS-32 Lamp)	COVERAGE (Degrees)		LUMEN OUTPUT (using BS-32 Lamp)	
			1/2 max. W x H	1/10 max. W x H		1/2 max. W x H	1/10 max. W x H	1/2 max.	1/10 max.
LQBM-10F (Multi-Broad)	Medium	230	12' x 7'	20' x 14'	32,000	55° x 35°	82° x 62°	11,300	19,260
	Wide	61	13' x 20'	24' x 27'	10,000	59° x 81°	91° x 99°	11,500	14,300

FIGURE 27 PERFORMANCE CURVES OF VARI-BEAM AND MULTI-BROAD LIGHTS



Figure 26. Vert-Beam Mounted on Tripod and Equipped with Barn Doors

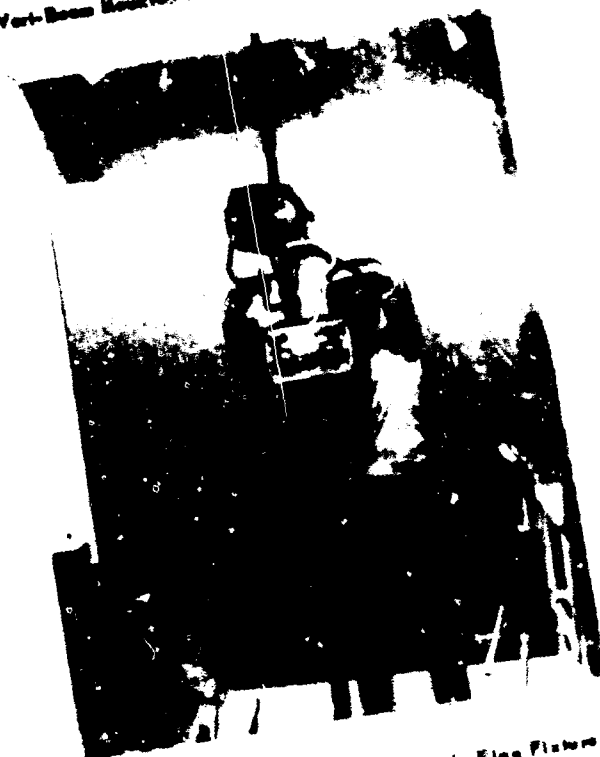


Figure 27. Lights Mounted on Pole King Platform

SECTION IV

RESULTS

This section presents the results of using the video tape recording (VTR) technique on the AN/APQ 120 radar, the Martin Baker Mark H7 ejection seat, and several other subsystems, systems, and equipment in various stages of development including: trial installations of the AGM65A missile on the F-4E aircraft, RF-4C 'update' mock-up demonstration, weapons loading procedures, Rockeye MK20, Mod. 2 Technical Order validation, functional eye position derivation, and the installation of the A/A 37U-15 tow target.

The video tape recording equipment was shipped to Edwards AFB, Category II site. The use of the VTR system involved the recording of images, access to classified areas, and the recording of classified material. All security provisions were made and proper identification acquired. The total field testing time remaining after preparation was sixty working days.

The Category II test was in its second year of testing. Most of the significant problems with the F-4E aircraft have been reported in the F-4E progress reports. It was felt that simulation of problems already remedied, just to make video tape recordings, would not be worthwhile. Several factors severely restricted the evaluation of the subsystems. One was weather conditions. California experienced one of the worst winters in history. Frequent rains, heavy winds and cloud cover restricted the test flights. This, in turn, minimized maintenance activity. It was not that the aircraft could not take off, but testing usually requires good conditions for assessing the results of the test, and to assure that the various test parameters have been met. Secondly, the radar subsystem had undergone a series of changes and was performing much better than had been anticipated. The radar did not fail during the field assessment phase of this study.

Maintenance on the Martin-Baker Ejection Seat was similarly reduced. Removals to allow access to other subsystems was the only activity involving the Martin-Baker Seat.

The effects of the reduction of maintenance on the two selected subsystems was partially offset by a series of demonstrations and tests on other equipment in earlier stages of development. The results of using the new PSTE techniques on these tests are included in this section. These tests provided unique and significant information on the use of the VTR technique during designs and development.

The PSTE team that originally manned the F-4 Category II test was reduced to five persons at about the time the field phase of this study started, and was further reduced to only one person, the contractor PSTE representative, shortly thereafter. The balance of the team was transferred to other test programs, primarily the C-5A and F-111A tests. The ATC personnel, formally part of the F-4E test, returned periodically to work with the VTR technique.

They also participated in some of the recording sessions. Their knowledge of the subsystems, facilities, and maintenance schedule was an asset to this study.

The results of using the VTR technique with the two selected study subsystems will be reported first. These will be followed by the results obtained in other test areas.

AN/APQ 120 RADAR

Several radar shop operations were investigated for the purpose of evaluating the usefulness of the VTR technique. The first area of interest was an overall evaluation of the usefulness and efficiency of operation of the VTR in a shop environment. We also wanted to determine the capability of the VTR technique in the identification of critical tasks while the radar bench equipment was being tested, and the capability of the VTR to render complex control and display indications in an typical maintenance situation. The radar shop environment and operations permitted an evaluation of some alternative methods of performing test voltage checks. Finally the VTR was used to evaluate a task involving the removal and replacement of a heavy piece of equipment. This evaluation included photographing still scenes from the VTR image displayed on a monitor.

Prior to final selection of the test site, we determined that all sites were equipped with the necessary subsystem AVE and AGE. At Edwards AFB the radar bench equipment was installed in the maintenance hangar approximately 3/4 mile from the F-4E Category II hangar. This hangar provides field level support for the system tests at Edwards AFB. Most of the work done in this area is classified and special provisions were made for video taping.

The video tape recorder cart was towed to the maintenance hangar via the taxi ways with a standard Air Force tractor. The tractor was left at the hangar door, and the cart was hand towed into the area occupied by the test bench.

The radar bench consists of an airborne system and the test equipment configured into a hollow square with the radar package occupying an island in the center. The video tape recorder cart was placed outside of the square because it would interfere with the operators' access to the equipment. Only the camera station was used within the square.

The F-4E radar bench was manned by the Tactical Air Command (TAC) and the Air Force System Command (AFSC) maintenance personnel. This team was part of the F-4E Category II test team and worked at the F-4E hangar as well as the radar bench site performing both organizational and field level maintenance.

Overhead fluorescent lights provided adequate illumination for the tasks associated with the bench. However, for video taping a higher level of illumination was required.

As was pointed out there was no maintenance activity on the radar system due to a lack of failures. It was decided to work on those tasks associated with preparing the bench for maintenance on the AVE. These tasks involved a series of built-in-tests (BIT) that are used to confirm that the test bench equipment was performing properly before working on defective or suspect AVE units.

The author talked with the sergeant in charge of the test bench and informed him that it would be desirable to record the tasks involved in performing the BIT on the equipment used to check out the front and rear cockpit indicators and their associated control panels. The sergeant in charge gave his permission to go ahead. An Airman Second Class volunteered to perform the task, and was briefed on the technique and its requirements.

In order to provide for audio annotation the person performing the task was asked to read aloud the Technical Order and then perform the task. A microphone with a lavalier attachment was hung around his neck to leave his hands free to perform the tasks. The video portion of the recording covered the accomplishment of the task, the manipulation of the controls and the resultant reading of the displays. The zoom lens provided for orientation (wide angle) and detail (telephoto) data.

The camera/operator station was located to the left of the equipment at a distance of 15 feet and the camera was elevated to a position that would best cover the equipment complex. The noise generated by the hydraulic and cooling systems of the bench tended to mask the technician's voice and a headset was used by the author to monitor sound level.

It was found that the task could be closely followed with the camera. One of the factors that influenced the promptness of getting the camera on the control and display was degree of familiarity with the equipment. When the T.O. specifies positioning of a control, the camera should be positioned quickly to pick up this control before the task is accomplished. A similar procedure should be used with displays. Knowledge of which unit is going to respond to the control allows one to quickly pick it up with the camera.

Since the indicator BIT check is frequently performed, it was decided to use the video tape recording as a basis for a more detailed analysis. In order to categorize the task elements, a miniature event recorder was used to time the various functions. The eight channels on the event recorder were used to record the following:

- a. Channel #1 T.O. Reading
- b. Channel #2 Panel Control
- c. Channel #3 Antenna Control
- d. Channel #4 Meter Reading
- e. Channel #5 Radar Indicator Display Reading

- f. Channel #6 Aid from Supervision
- g. Channel #7 Special Interest Mark
- h. Channel #8 Not Used

The results of this analysis are presented in AFHRL-TR-69-16 "Miniature Event Recording as a Technique for Personnel Subsystem Test and Evaluation." Performance of this analysis in real time would not be possible because of the speed of the action. Also, decisions must be made as to the most meaningful categorization of functions.

On two occasions, the airman interrupted the sequence to ask the supervising sergeant why he was not getting the display that he thought he should be getting. On another occasion the correct image on the radar was not displayed. Upon checking with the sergeant, it was determined that he (the technician) had failed to start the hydraulic power supply. This is one of the first steps. This error led to the examination of the technical order to establish whether it was a T.O. omission or whether the technician overlooked a step. The result was that the airman had forgotten to turn on the hydraulic power and was relying on memory rather than using the technical order during the initial preparations.

Thus, the capability of the video tape technique to preserve the task and to permit recovery of the information, quickly aids in establishing when and how errors occur. Depending on the error source, steps can be taken to prevent future occurrences.

One of the unexpected benefits of video taping this particular task was the discovery of the ability of the technique to render high quality radar images of the radar indicator. Most of the task recordings showed the operator selecting the control position and the resultant image on the radar scope. However, by decreasing the brightness control on the monitor, the radar image could be enhanced. The recordings contain much more information than one obtains with fixed monitor "contrast" and "brightness" settings. Frequently images that contain very dark shadows can be improved by reducing the contrast, thereby rendering details in the shadows. Most of the work done with this technique was performed under conditions far removed from those experienced in a television studio. Yet, the results contain detailed information useful in PSTF, and by frequent playback an enormous amount of data can be derived. This is not to suggest that all recorded tasks be 'beat to death' by incessant replaying. Rather, a good detailed recording can provide the basis for a wide range of evaluations when required.

The aircrews have complained that the BIT takes too long and is too complicated. At the time of this writing, the video taped recordings of the BIT checkout are being used to establish times and task difficulty. It is too early to determine what influence this analysis will have on the radar BIT design and aircrew procedures.

Although not reported as a problem, the desirability of having a digital voltmeter as part of the radar bench came up in one of the casual discussions with the radar contractor representative and the maintenance men. It was reported that the differential voltmeter provided with the bench, while being accurate and rugged, consumed a great deal of the technicians' time in obtaining readings.

The test of the computer test set which required many of these voltage readings was video taped. This test involved setting the controls on the test set in various modes and then taking a reading on the voltmeter. This test is performed on the bench equipment prior to checking out the AVE radar computer. The checkout of the computer is associated with missile launchings, and due to the high cost of missiles it is necessary to assure a properly working computer.

The technical order defines the positioning of the various test set controls, and specifies the proper voltage with the acceptable range. These voltages may be AC or DC, and may be negative or positive if DC.

The technician must select the proper meter sensitivity, AC or DC mode, and polarity for DC voltages before inserting the signal into the meter. The computer test set has an amber light that warns the operator to check his test set and meter setting to avoid error and damage to test equipment.

The differential voltmeter can also be used as a vacuum tube voltmeter VTVM. The technician sets the NULL switch to "VTVM" position and sets the five vertical dials, A thru E, to "ZERO" positions. The RANGE switch is positioned to 500 and the AC-DC polarity switch to the position that coincides with the type of voltage to be measured. The voltage is then inserted into the voltmeter by pressing the METER switch button on the computer test set. An approximate voltage can then be read off of the upper scale of the null meter. If the voltage is low, the technician can then turn the range switch to a lower value; the meter then has a full scale deflection of 50-0-50, 5-0-5, or .5-0-.5 depending upon the range scale setting. Once the approximate voltage is known the following procedure is used:

After either deriving the approximate voltage as defined above, or by using the expected voltage as called out in the T.O. procedures, the technician dials in the value on the five vertical dials A thru E, and positions the RANGE switch to give the lowest range that will give an on-scale meter reading. A decimal light will position for each range setting (between vertical dials). This light indicates to the technician the proper place to dial in the numbers. In Figure 30 the decimal light is on between the 2 and the 3, therefore Dial A (not in picture) is 0, and the setting of all five is A-0, B-1, C-2, decimal D-3, and E-4 to indicate 12.34 volts.

If the actual voltage does not match the expected voltage, the meter will go to the right, indicating higher than actual, or to the left indicating lower than actual. By determining the extent and direction of the deviation, the A-E dials are changed until the meter nulls on the range setting, and then the NULL switch is changed to a more sensitive setting and the procedure is

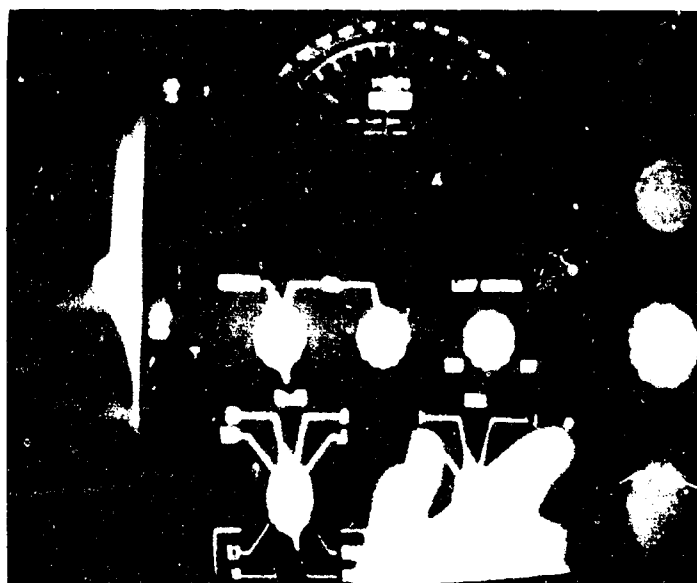


Figure 30. Scene from Differential Voltmeter Nulling Task Taken From VTR Monitor

repeated until the lower, C-E dials null the meter. The actual voltage is that reading on the A-E dials that nulls on the most sensitive NULL switch position. It may not be necessary to achieve nulling on the D & E dials if the tolerance on the voltage is large enough to require only two or three digits.

A digital voltmeter requires only a fraction of the manipulations defined above. Only gross sensitivity selection and the selection of AC or DC are required on most meters of this type. The actual voltage is displayed on (nixie) tubes and can be read directly.

Video tape recordings were made of T.O. voltage determinations using both the differential volt meter and digital voltmeter. A digital voltmeter that could measure AC voltages was unavailable for these trials so only the DC voltages in the test set checkout were performed.

A miniature event recorder was used to obtain a record of the various task functions as recorded by the VTR technique. The selected functions were:

- a. Reading of the T.O. step.
- b. Performing the computer test set control adjustments.
- c. Performing the voltmeter control functions.
- d. Inserting the voltage.
- e. Nulling the meter (differential only).
- f. Reading the display.

Results showed the average voltage determination required 4 seconds on the digital voltmeter and 28 seconds using the differential voltmeter. Although the superiority of the digital voltmeter for making direct voltage readings was demonstrated, additional factors must also be considered before making a decision to convert to digital voltmeters for the radar test bench. These factors are accuracy, versatility, frequency of use, cost, and compatibility with the test equipment. There are digital voltmeters that meet the technical criteria. However, the justification for the added expense presents another problem. A conversion to more expensive equipment might prove to be economical if the manpower savings were significant. A test at the Category II test site with one radar and one test bench cannot determine frequency for use. But, if an event recorder were connected to those differential meters being used by the operational units to record their frequency of use over a period of time, the time that could be saved by changing to the digital type could be determined. Of course, the time savings should be projected to the total number of units using this equipment, and to the expected system lifetime.

While the video tape recorder was being used in the radar shop, technicians pointed out that the removal of the radar antenna was complicated by the design of the bench and by the lack of a special piece of AGE. The radar

antenna is removed so that a malfunctioning or suspect antenna can be checked out with the balance of the subsystem. The radar antenna weights 42 lbs. An extender, bar slide rail, is used on the aircraft to extend the radar package forward so that its components are accessible. The radar bench was not provided with this bar and the technicians must assume awkward positions to perform this task on the bench. The bench structure beneath the antenna prevents the personnel from getting under the antenna. The removal requires two men - one on each side of the bench. They have to support the weight with their arms extended. To complicate the removal, there are several delicate components below the antenna that could be easily snagged or dented during the removal process.

An analysis of this task as recorded on VTR indicates potential injury to the personnel and damage to the radar antenna due to a lack of positive control of the weight. At present, operational units can order the extender, slide rail, Part No. 53E340018-1 to correct this problem.

A series of still photographs was made from the monitor screen to document the technicians' body positions during the task. The radar antenna is a classified item and these pictures cannot be presented in this document. However, it should be pointed out that still pictures taken from the monitor screen at critical points of a task provide data for anthropometry, work space layout, and other measurements involving man and the equipment.

MARTIN BAKER MARK H7 EJECTION SEAT

The results of using the VTR technique on the Martin Baker Mark H7 Ejection Seat maintenance include evaluation of the VTR equipment when used in a congested shop area. These results also include critical tasks, including hazardous tasks involving pyrotechnic devices. Analysis of the VTR recordings demonstrated their suitability for detailed task analysis and development of procedures for training, maintenance, and quality assurance. These analyses also provided identification of maintenance tasks that consume excessive time because of inadequate design.

Martin Baker Mark H7 Rocket Ejection Seat maintenance involves a multitude of critical tasks. Due to the nature of the seat, which is an emergency egress system, the performance of nearly every maintenance task has the potential of degrading the seat system's performance. The seat contains pyrotechnics in the form of a rocket motor, a catapult gun, drogue gun, a guillotine gun, and a gas powered inertial reel.

During the field verification phase of this study, seats were being removed and replaced in the aircraft only to allow access to other cockpit equipment. The video tape recording of tasks associated with other seat maintenance requirements were made before and after the field phase. A large number of these tasks were recorded. They include:

- a. Preparation of rocket motor for installation on seat.
- b. Mounting of rocket motor on seat.

- c. Insertion of firing mechanism.
- d. Quality check of firing mechanism.
- e. Safety lock on firing mechanism.
- f. Lock wiring of rocket motor tubes and firing mechanism.
- g. Routing of leg restraint cords.
- h. Installation of leg guard plates.
- i. Assembly and disassembly of catapult gun.
- j. Cleaning and lubrication of catapult gun.
- k. Insertion of primary catapult cartridge.
- l. Mounting of drogue gun.
- m. Interconnection of drogue gun with time release mechanism.
- n. Test of time release mechanism activating drogue gun firing mechanism.
- o. Pressure chamber check of time release mechanism.
- p. Adjustment of time release linkages.
- q. Installation of drogue chute pack assembly.
- r. Installation and arming of guillotine firing mechanism.
- s. Quality assurance on face curtain handle, secondary ejection handle and lap belt break out forces.
- t. Installation and removal of seat bucket.
- u. Mounting of gas initiator for inertial reel.
- v. Routing and attachment of ballistic gas line.
- w. Quality check of inertial reel.
- x. Lockwiring of most of the above.

The preparation of the rocket motor for mounting on the seat bucket involves some work that could be circumvented. The rocket motor is received from the supplier with all of the rocket tube caps lock wired. However, when this motor is mounted onto the seat bucket, the leg restraint cords must be routed between the tubes. This cannot be accomplished with the lockwires in place. Therefore, they are cut and removed. The restraint cords are then

slipped between the tubes, and the tube covers are lockwired again. The total additional work required for the cutting, removing, and lockwiring is 6 minutes. This task must be repeated each time the motor is removed from the seat bucket. One solution of this problem is to redesign the fitting on the proximal end of the leg restraint cord so it can be attached after the cords have been threaded through the rocket tubes.

The task of mounting the gas generator into its clamp indicated that the clamp had to be modified by many bending and forming actions to achieve a proper fit.

These two equipment design problems highlighted by means of the VTR technique have been forwarded to the appropriate engineers for resolution.

Although there were no unforeseen problems identified through the video tape recordings, the technique clearly identifies the critical tasks involved with field maintenance. (see Figures 31 and 32). The recordings contained enough detailed information that they could have provided for writing of technical orders or training. Some of the elements that could improve procedures and training were:

- a. Identification of tools and test equipment.
- b. Orientation of the component relative to the seat.
- c. Description of the method of mounting and the sequence of mounting the component.
- d. Description and demonstration of quality checks with expected and actual test criteria.
- e. Identification of those in the tasks that are subject to precise movement.
- f. Identification of hazardous tasks and cautions to be observed.

TRIAL INSTALLATIONS OF A DEVELOPMENT STAGE MISSILE

The use of the VTR technique for missile and missile AGE operations included introduction of the VTR to a contractor's test series and the comparison of the VTR technique to movie camera recordings during tests. These evaluations with a missile system also provided identification of critical tasks and equipment problems. Additional information is provided regarding attitudes of test personnel after an adequate VTR demonstration.

One of the most important evaluations of the VTR technique was demonstrated in its use on the trial installations of the AGM65A, Maverick missile on the F-4E aircraft.



Figure 31. VTR Detail of Lockwiring Rocket Tube Cap*



Figure 32. VTR Detail of the Insertion of Firing Pin Mechanism*

* These pictures were taken directly off of monitor during VTR playback.

The McDonnell Douglas Facility at Edwards AFB is the Category I test site for the F-4E aircraft. It also serves as the test site for other McDonnell Douglas aircraft and for new subsystems in the research and development stage. The management of this facility had been briefed on the purpose of the PSTE study and upon the capabilities of the techniques. They were asked by the author to alert him to any tests that involved equipment in early design stages.

The author was notified that the Hughes Aircraft Company was to make some trial installations of the AGM65A missile and its launcher.

After being introduced to the Hughes personnel, the author was briefed on the conditions applicable to the test. The exterior view of the missile was classified. No video recordings were to be made unless the movie cameras were also running. This requirement was to preclude video tape recording sequences that showed problems. The movies were being made primarily for promotional purposes.

It was pointed out that this trial installation was a first attempt, and that some problems might occur. These problems would be solved in the production article, and to record them would be misleading the viewer of the recording. The author agreed to abide by these rules for he had no authority or responsibility on this project.

After nearly twenty minutes and several minor problems, e.g., the lift truck forks would not engage the launcher adapter holes. The author was asked by a Hughes AGE engineer if these sequences had been recorded on tape. The answer, of course, was "no". The engineer was informed of the restrictions that had been specified by Hughes. Thereupon this engineer, test management, and the author had an informal conference. It was agreed to let the author record any parts of the tests with the provision that the tape would be rerun at the conclusion of the test and any scenes that Hughes Aircraft personnel didn't want recorded would be erased. In addition Hughes was to be provided with a duplicate copy of the tape for their use. From this point on, the VTR was used almost constantly. The recording was only interrupted when no work was being accomplished, e.g.; lunch time, and group discussions.

Shortly thereafter, the advantages of the VTR technique began to become apparent. The AGM65A launcher with dummy missiles was to be mounted on the F-4E. The mounting operation consisted of a MJ-4 bomb lift truck with forks engaging a launcher adapter which held the launcher with its preloaded missiles. The MJ-4 positioned the load under the aircraft's pylon and lifted the launcher with missiles to a point where the lugs on the launcher could be engaged with the pylon hooks.

After the pylon hooks engaged the launcher lugs, the launcher adapter was disengaged from the launcher and the MJ-4 withdrew it from beneath the wing. The disengagement of the launcher adapter indicated that the technique and procedure for removing the pins that held the launcher to the adapter and the folding down of the adapter's arm was a critical operation. The MJ-4

had to relieve the downward force of the load to permit pins to be withdrawn. This required careful manipulation of the MJ-4's roll, lift, tilt and other controls. In addition, the folding of the arms could not be accomplished unless there was adequate clearance beneath the launcher. These problems, the author was informed, would not be present in the production equipment. It was obvious that the sequencing and technique as recorded on VTR would provide important data to engineering, technical writers, and training personnel. The sway braces on the launcher were then tightened to stabilize the load.

When the installation had been completed, the missile complex was removed from the pylon. The MJ-4 positioned the launcher adapter beneath the pylon and elevated it to a point where the arms were unlocked from their prone position and rotated and locked into a vertical position. Again, the point at which the arms are rotated is a critical position and should be defined in T.O. procedures.

The alignment of the adapter to the launcher in order to pin them together was the most time consuming point in the trials. This can be accounted for in several ways. Under first time test conditions like these there are too many individuals giving direction. The lack of established procedures contributed to the confusion. However, it must be said that the alignment of four holes on the launcher and four holes on the adapter presented a difficult task because of the close tolerances, poor visual access to the MJ-4 operator, and the lack of self alignment features. Here again, the engineers stated that this sort of problem would be solved in the production articles and the recording of this sequence would be misleading. It was pointed out by the author that a copy of the recording would be provided to Hughes Aircraft for their use, and that these data would not be used to document design discrepancies. Only a limited amount of this task was filmed.

After the launcher was secured to the adapter, the hooks on the pylon were disengaged. The MJ-4 forks had been raised slightly so that the weight of the launcher and missiles was supported by the launcher lugs. When released the launcher and missiles descended downward for a short distance because of the slack in the fork lift holes on the launcher. However, it was thought that there may have been a lateral movement. This sequence was not documented on movie film but had been recorded on VTR. The video tape was rewound and the scene was played back. There was a decided lateral movement. This movement cracked one of the missile's fins against the pylon. The lateral movement could be accounted for by the unknown lateral (inboard) forces built up during the attempts to align the holes for pinning. Since there was no feedback that this force existed, no precautions were taken to avoid its effects. It is not known at this time under what conditions this would occur in an operational squadron but it is fully documented and could lead to design and procedure changes that would preclude its' happening. The capability of the VTR recording to capture critical events such as this and then to recreate them in a matter of a few minutes is one of VTR's unique and significant attributes.

Several other minor events were recorded on the tape in addition to those described above. The entire recording was replayed for Hughes personnel to

determine if any sequences should be erased. No erasures were requested. Instead they expressed overall enthusiasm for the recording and technique.

The next day the Ampex tape recorder was used to play the original video tape into the Bell and Howell recorder to make a duplicate audio and video tape. The copied tape was forwarded to Hughes Aircraft. A description of procedures for making duplicate video tapes is in Appendix I.

About a month later the AGM65A personnel returned to the McDonnell Douglas facility to make trial installations of the missile on a launcher already mounted on an F-4E aircraft. This task involved engaging the missile rails with the launcher rails and sliding the missile into place. Several unique pieces of AGE were required for these tests. Similar tests had been conducted on the F-111A, but the author did not attend this demonstration.

While awaiting the arrival of the missile and AGE from the F-111A hangar, the McDonnell Douglas security guard informed the Hughes Aircraft personnel that the base photographers were at the guard shack, and wanted to know if Hughes had requested them. Hughes' personnel answered that they could use the still photographers but would not need movies because the VTR was there. They also remarked that the VTR was better than movies for what they were going to do. It was obvious that the VTR technique had proved itself on the first demonstration.

This entire series of trials were recorded on video tape with no interruptions while work was being performed. Several task elements consumed a large amount of time. One of the critical tasks was the alignment of the missile rails with the launcher rail so that a smooth and complete mounting could be made. Due to the close tolerance between the two rails, very precise alignment had to be established before an aft movement of the missile could be made. The requirements for alignment and the corrective action for improving this procedure could be derived in part from the VTR recordings.

Accessability of the electrical connector in the pylon is poor. The pylon, door containing the connector hits the missile fin and therefore cannot be fully opened. In order to accomplish the connection between the launcher and the pylon one must go to the rear of the right hand missile, reach forward and into the "V" shaped opening made by the partially opened door, they make a turn with the wrist until the hand is inside the connector cavity. The task of connecting the launcher cable to the pylon connector is effected with no visual access. The manual access is difficult because it requires a long reach. Personnel with short reach have difficulty engaging the connector.

Two hours of recordings were made during these trials. Duplicates were made from the original and forwarded to the Manager of AGE for the Maverick missile. At the time of this writing no information is available on the use of this tape record.

RF-4C AIRCRAFT UPDATE MOCKUP EVALUATION

This use of the VTR was to develop data for system design during the proposal stage. Just prior to the field phase of the PSTE study, the author was given the opportunity to video tape the RF-4C update mockup including the procedures involved in removing and replacing the new subsystems and new aircraft structure. The video tape recording system as modified for field work was not yet available and the mockup recordings were made under marginal conditions of mobility and illumination.

Two days were spent observing and recording the practice runs of the mock-up crew. Care was taken to cause minimum interference. After the formal mock-up demonstration, the author was informed that he could utilize the mock-up crew to perform the tasks as required. The person responsible for the personnel subsystem sensor maintenance was on vacation. Therefore, it was decided to concentrate on those tasks that could be considered critical, for the load crew and equipment would not be available when the PS man returned.

One of the problems of mock-up video taping stemmed from the fact that all of the sensor boxes were painted black and all of the maintenance personnel wore white coats. The vidicon tube integrates the total light falling upon its face, and when exposure is adjusted for the white area, the shadow or darker area is rendered black. If exposure is set for the dark area the white blooms up, losing all the detail. The system may even go negative because of being overdriven. This light environment was a very difficult one in which to work. However, adequate recordings were made.

Most developmental mockups are not fabricated in detail, and one must recognize that plywood, sheet metal, and conceptual hardware do not possess the fit of machined equipment. Mock-up boxes are infrequently weighted to simulate the end item. Tasks involving mock-up equipment must be judged in terms of production equipment.

The mock-up crew was most cooperative and explained some of the design concepts to the author. On several occasions some of the equipment not being worked on was removed to give the video camera a better view of the proceedings.

The video tape recordings were reviewed by project engineers, project PS personnel, and by the F/RF-4C office PS monitor. The general consensus was that the recordings represented the mock-up well. However, some engineers thought that the recordings were too negative. That is, they dwelled on design problems.

It must be admitted that the recordings did concentrate on those areas that might create problems, such as alignment, weight handling, visual and manual access. The engineers stated that a later version would not possess these problems once the project was underway.

The mock-up did reflect significant design improvement over the current RF-4C. An hour or two could have been spent documenting the improvements. This indicates that the data derived by the VTR technique is highly dependent on the discipline and responsibilities of the person doing the recording. Purely promotional documentation is better left to the movie camera with its high resolution and color capability. Wringing out a design can be handled better with video tape recording because of its ease and economy of operation, rapid playback, good quality audio, and its ability to record lengthy scenes.

WEAPONS LOADING TASKS

A field trial of the VTR was conducted at Nellis AFB to test the equipment under Category III test conditions, and to expose the technique to the operational personnel. The author was informed that some weapons loading tests were going to be made at Nellis AFB during the later part of February 1969. Upon concurrence with the technical monitor, preparations were made to move the equipment from Edwards AFB to Nellis AFB, a distance of 260 miles.

Originally the equipment was shipped from St. Louis to Edwards AFB via commercial freight in packing boxes. It was decided to attempt to move the equipment to Nellis by means of a rental trailer. The conventional van type was not used because of the potential difficulty of loading and unloading the cart. Instead, an open stake type was selected that had a heavy tailgate that could be used as a loading ramp. It was possible for one man to load the VTR cart into the trailer. The cart was secured within the trailer with rope. Because of impending rain, the carts doors and meter housing were taped to prevent water getting into the storage areas and the voltmeter. The VTR and lights were stowed in the car trunk. The trip was uneventful except for heavy rain and wind.

At Nellis the TAC maintenance officers were very interested in the VTR technique and offered valuable suggestions as to where best to apply it. They also discussed some areas where the VTR might be continually used in their work. One of the most promising applications would be in the establishment of weapons loading standards.

The formulation of loading standards requires the optimization of the load crew with a special emphasis on safety. The VTR would permit a group of experts to assess trials and formulate effective procedures.

A demonstration of the VTR system was conducted for the standardization team. They were impressed by the rapid playback, quality of image and voice, and the maneuverability of the camera/operator station. The standardization personnel suggested that the load crew certification exercises planned for the next day would provide useful data and a test of the technique. The certification personnel were contacted, and agreed to the test.

Normally, load crew certification is conducted outside on the "hot line", but due to a storm front, it was moved into a hangar. The munitions used for these exercises are inert. However, they are weighted to simulate the weapon.

The fuses, fins, arming wires and other parts that have to be used are identical to the actual hardware.

The certification requires the load crew, the load crew chief, and the certification team; for a specific weapon, the load crew chief informs his crew of the place, time, and loading. In addition, he describes the precautions that have to be taken. For example, clearance around aircraft of 500 feet, requirements for fire fighting equipment and other safety steps. Then the load crew begins a step by step preparation of the aircraft by removing all pyrotechnics. In order to assure that each element is accomplished, the crew responds to each order by calling out the station he is checking; right, left, center. The cockpits are checked for the positioning of switches and circuit breakers and a stray voltage check is made. Only after these steps are taken does the crew start preparing for the weapon itself.

No attempt was made to slow down the loading task to get a VTR. However, it was soon apparent that the load crew and load crew chief were widely dispersed, and that detailed recordings of what one individual was doing would result in no record of what the balance of the team was doing. No attempt was made to record the tasks being performed in the cockpit.

As most of the preparation for the weapon was performed beneath the fuselage and wings, another shortcoming of the equipment was evident. The tripod and camera could just clear the overhead, and the camera's access to the cavities was very limited. In the future, this can be overcome by acquiring a fixture that mounts on the tripod but positions the camera as low as floor level. Even with these restrictions, meaningful data was acquired. Detailed scenes of sway brace adjustment, lug engagement, and crew interactions were taken.

The load crew is graded on its performance and is informed of any discrepancies. One indication of how complex a task it is to assess their performance is that on two occasions the crew was told that they had omitted a step. The individual crew members insisted that they had performed the step. Replay of the tape confirmed that they had in fact performed the step. On the other hand, the recording confirmed that the crew had violated some safety precautions by having their hands between the bomb and the fuselage while it was being elevated by the bomb lift truck.

It is not suggested that recordings be made of all load crews hanging all weapons. However, VTR can provide quick and comprehensive training. On tasks such as weapons loading it is obvious that several cameras must be used or that the loading be duplicated from several camera positions to acquire adequate data.

A total of five weapons loadings and unloadings were recorded. These tasks typify the situation where the use of a microphone cord is unsatisfactory.

Detailed VTR data would provide operational personnel and design engineers with information regarding turn around time, mixed load problems, and areas requiring improvement such as stray voltage checks and fusing.



Figure 33. Rigging of Fuse Wire*



Figure 34. Load Crew Installing Bomb on F-4E Pylon*

* These pictures were taken directly off of monitor during VTR playback.

One factor that should be discussed is the possibility that people might fear and resent the intrusion of the VTP technique. At the Nellis AFB trials the author met load crew for the first time. The justification for the test was explained to them. Simply stated, this was: the technique itself was being tested. All through this study there was a wide variety of personnel being recorded and not one objected on the grounds of an invasion of privacy. This, of course, does not mean there will be universal approval. On two occasions bystanders stated that they would not want to be recorded performing their work. It is suspected that the persons who will object most violently are those who know they are inadequate or believe that they are. Precautions should be taken to avoid making this technique a "big brother" type operation, or forcing it upon those who object.

ROCKEYE MK 20, MOD 2 TECHNICAL ORDER VALIDATION AND FIN HAZARD

A T.O. validation was scheduled at the McDonnell Douglas Facility for T.O. 1F-4C-33-1-2 check list. Two MDC technical writers visited the test site to validate their procedures against the actual loading of the weapon. A video tape recording was made of the check list which included the following:

- a. Aircraft Preparation
- b. Munition Preparation
- c. Preinstallation Inspection
- d. Loading
- e. MER, TER, Installation
- f. Post Loading Inspection
- g. Cartridge Inspection
- h. Immediately Prior to Launch Inspection
- i. Delayed Flight and Alert Safing
- j. Safing
- k. Unloading

There were no significant results from the video tape data. At times personnel performing the loading had their hands in positions where serious injury could occur, e.g. between the bomb and MER structure when the lift truck was elevating the weapon. Due to unusual circumstances, the persons performing the task were not those who normally perform weapons loading. The difference between the recordings for this installation and those of the Nellis AFB load crew impresses one with the importance of training in regard to safety and effective ordnance loading.

The flight test engineers were interested in the potential hazard and the characteristics of the Rockeye bomb fins. These fins are spring loaded and are retained with a steel band until launched. A test was planned in which the pin holding the retaining band would be released allowing the fins to spring out. Both slow motion moving pictures and video tape recordings were made of this test. The playback of the fin movement showed that not only were the fins a hazard because of the speed and force with which they deployed, but the retaining band would whip around creating a hazard to the eyes. Since the strap would move beyond the fin envelope the safety zone would have to be enlarged to allow for this characteristic. In addition, the fin and strap deployment had significance in so far as separation from the aircraft was concerned. The slow motion movies when developed were much more detailed than the VTR image. Yet, the VTR was capable of documenting the basic hazards.

ANTHROPOMETRY

The VTR technique was used as an aid to define a complicated human factors technique for relating the functional eye positions of the pilots to the structure of the F-4E cockpits.

During the field test of this equipment, a McDonnell Douglas anthropologist visited the Category II test site. The purpose of his visit was to develop some data on the functional eye positions of the pilots. The technique he was going to use involved the aircraft, the pilots assuming a flying position, and a transit. The transit was used to relate the eye position of the pilot to known structure of the aircraft. The trigonometry of this technique will not be covered in this report. However, the steps taken to achieve these measurements were recorded on video tape. This information was later reviewed by the contractor PSTZ representative in order to accurately report the eye position data and the technique by which it was derived. One of the means of explaining this technique consisted of the anthropologist sketching the procedure step by step with chalk on the floor of the hangar while explaining it verbally. This chalk/blackboard technique would be very valuable in circumstances where a complex description or explanation must be given step by step development.

USE OF PORTABLE AUDIO RECORDER TO OBTAIN VOICE FOR VIDEO TAPE

One of the problems experienced with video taping in hangars and shops was getting a good audio track. Two factors contribute to poor audio. One is the high ambient noise level and the second is the problem of keeping the microphone wire where it will not interfere with the tripod dolly, get entangled in equipment, or cause someone to trip. Yet, the audio track provides valuable annotation and an effort was made to devise a better method. One of the methods that proved to be useful was recording the sound on a Sony Model 100 portable tape recorder. This unit is powered by batteries and is small enough and light enough to be carried on the shoulder. The sound recorded on this recorder is dubbed on the video tape at a later time. A description of this technique may be found in Appendix I. With reasonable care the dubbing will be good enough to achieve lip synchronization with the video portion.

INSTALLATION OF THE A/A 37U-15 TOW TARGET

The F-4E Category II test was evaluating the installation, launching, and aircraft towing of a tow target. The VTR technique was used to evaluate the installation of the POD that supports the target and contains the cable reel that deploys the target when it is airborne. Examination of the video tape data indicated that this task would have to be recorded from several angles and would require low camera positions. Additional recordings were not accomplished because the task was not repeated when the VTR equipment was available.

SECTION V

ASSESSMENT AND RECOMMENDATIONS

The assessment and recommendations of the VTR technique will be presented in two parts. The first part is assessment by the disciplines involved in the testing, design, and support of weapon systems and subsystems. The second part is the assessment and recommendations regarding the equipment used in this study along with suggested improvements.

ASSESSMENT BY TEST DISCIPLINES

In order to determine the potential of the VTR technique, it was planned to expose its use and data to as many test sections as possible. Disciplines such as design, training, technical writing, and maintainability were also given demonstrations of its use. A wide variety of test, design, and supporting functions saw the VTR equipment in use and had a chance to review the tapes. However, most of these sessions were brief and imparted limited information. Further exposure and experience with the data should reveal additional applications of recorded task data.

Generally, the advantages of the video tape recordings over currently used methods such as direct observation, maintenance reporting forms, questionnaires, and checklists was so obvious that the VTR technique was accepted at first sight.

Many persons were totally unfamiliar with the equipment, and some did not know that relatively small video tape recorders were available. The quality of the audio and video data, the fast playback capability, and ease of operation were the most impressive features. With very few exceptions, the VTR technique was regarded as a new and valuable tool that should be used in testing. Most of the questions asked were those related to cost, applications, and the techniques involved in making copies. The only serious objection to its use was by some design engineers, who did not relish the wide distribution of recordings that showed task difficulties associated with their equipment.

Because the exposure to the various groups varied, and each group had somewhat different responsibilities, an assessment questionnaire was not used. The following generalizations are based on comments made during the study:

a. Air Force

(1) PSTE Management at Edwards AFB (Bioastronautics Division)

It was the opinion of the officers in charge of implementing PSTE on tests at Edwards AFB that the VTR technique had major deficiencies in so far as their effort was concerned. The following summarize their views:

- (a) VTR equipment is too expensive and the justification for its procurement would be extremely difficult.

- (b) PSTE officers in charge of PSTE programs would not have the time to use or direct the use of the technique, or to analyze the data.
- (c) PSTE team members would require too much training in order to use the equipment.
- (d) PSTE is a reactive process responding only to problems identified by the test force.

They felt that VTR had some advantage over current techniques but these would be outweighed by the deficiencies listed above. The use of VTR by the contractor during system development was suggested as an excellent place for VTR application.

(2) PSTE Management at Norton AFB

The Minuteman PSTE team captain had attended a Human Engineering Conference at which the plans for this study were described. He had requested a briefing on its progress, and this was accomplished late in the field phase. Several recordings were played and a demonstration of the equipment and its modifications was given. In his opinion the VTR technique would provide his team with valuable information. He was especially interested in obtaining a report of the results of this study and in methods of acquiring the VTR equipment.

(3) F-4 Aircraft PS Monitor

The Personnel Subsystem Monitor for the F-4 Aircraft Office (formerly the F-4 System Program Office) reviewed many of the VTR recordings. He has encouraged the application of the technique on F-4 PS elements, and has asked that it be demonstrated to the other PS monitors, especially with reference to its use in ordnance handling. His review of the recordings made of the RF-4C update mock-up tasks provided him with detailed information regarding maintenance of the proposed equipment. The F-4 Office does not have a play-back VTR so full advantage of these and other F-4 recordings could not be accomplished during the study.

(4) Program Management

Due to the lack of significant findings on the two selected subsystems, there was no exposure of the results of the VTR technique to the F-4 office management. The AGM65A System Program Office (SPO) management was not provided with the missile installation video tapes because the recordings did not represent a stage of development that Hughes Aircraft deemed suitable for formal evaluation.

(5) Maintenance and Ordnance Handling

The comments made by maintenance officers after being briefed on the VTR technique indicated that they believed it was an answer to one of their most serious problems; that of tracing down a problem to its specific cause.

They described several current problems that involved finding a way to prove that their personnel had performed their work properly and that the units were working to specification prior to delivery to the organizational level. One such problem involved documenting the fact that units received from the depot did not perform according to specifications.

Tactical Air Command (TAC) officers, munitions loading, and maintenance personnel regarded the VTR technique as a potentially valuable tool in establishing standards. It was believed that efficient standards could be formulated much more rapidly through the utilization of VTR recordings than with their current method of many live trials.

(6) Air Training Command

The PSTE observer evaluators who were transferred from the F-4E PSTE team shortly after the beginning of this study had more exposure to the VTR technique than anyone else on the test team at Edwards AFB. They believe that VTR would provide them with a fast, inexpensive way to develop specialized training materials. It would also provide a means of effectively utilizing the observer evaluators on PSTE by assuring coverage of tasks, identifying problem areas, and providing a means by which human engineering or life support specialists could be briefed on problem areas. They believed that tapes prepared prior to Category II testing would be a good way to brief Category II test personnel on system equipment and procedures for both training and PSTE. One of the ATC men was transferred to the F-111A program and began using the F-111A program video tape recorder (originally intended primarily for air crew and cockpit evaluation) on maintenance activities. His effort in this area was received with enthusiasm by the F-111A test management.

b. Contractor PS and PSTE Personnel

The McDonnell Douglas Engineering Psychology Department has been using the VTR for human engineering evaluation on F-4 aircraft and missiles, space reconnaissance, and advanced display simulations for several years. The potential usefulness of the VTR technique for PSTE was recognized very early by the F-4 Personnel Subsystem Group. It was believed that this technique would have applications throughout the PS elements and in all category tests.

The early use of the VTR was limited because of limited mobility and complexity of equipment components. Although many improvements were needed, the time required to implement these modifications was not available due to heavy project commitments. This study contract provided a means to implement the changes, and to apply and evaluate this technique on a wide base.

Engineering Psychology Department personnel at McDonnell Douglas, St. Louis interface with many of the design, support, and testing groups. Their requirements as well as those that are more exclusively the concern of the personnel subsystem activities can be partially met by the VTR technique. At this time, the Engineering Psychology Department is working with several design and support groups in the application of the technique to additional areas such as manufacturing methods and Time Compliance Technical Orders (TUTO's).

One of the McDonnell F-4 PS group has been on the F-4E Category II test since its beginning. This is the only person performing PSTE on this test program at the present time. Based on experience with the presently used PSTE techniques, and upon needs identified during the test, this person is convinced that VTR would greatly improve PSTE effectiveness.

c. Contractor and Vendor Engineering

The attitudes of engineers regarding the usefulness of the VTR technique varies with their responsibilities. To the design engineers VTR recordings present both a valuable tool and a threat. From the positive standpoint, VTR offers them a method by which they can evaluate their equipment being used. It aids in pinpointing problem areas and in formulating corrective actions. However, some are skeptical about the distribution of the video tapes. This is especially true for mock-up and early maintenance trials. They feel that the problems associated with these early events will not represent the production equipment, and that the recordings may give the viewers the wrong impression. However, many design engineers would utilize video tape data provided by vendors or the Air Force.

Test engineers regard video tape recordings as an excellent means of evaluating design and performance. Since they did not design the equipment these engineers are more favorable toward distributing the data to others. Video tapes made during this study have been used by test engineers to assure exact duplication of maintenance procedures. VTR data can significantly reduce the time and effort to prepare test reports, and aid the recipient in understanding the data.

ASSESSMENT OF EQUIPMENT AND RECOMMENDATIONS

a. VTR System Considerations

The VTR equipment used in this study should be compared with battery powered portable systems for use in PSTE of maintenance activities. The powered portable systems have some primary advantages. These are:

- (1) Mobility - The camera, lens, microphone, recorder, and battery pack weight less than 25 pounds.
- (2) Simple wiring and operation.
- (3) No monitor required - A small CRT in camera provides TV image for focusing, zoom, and framing.
- (4) No external power required - Powered by internal batteries or can use ground power if available.

There is no question that this type of unit is superior in mobility, cost, and simplicity. However, there are some serious limitations.

- (1) The recording cannot be played back on the portable recorder. It has to be played on a larger machine. A playback system with monitor weighs nearly 75 pounds and requires 115v 60 cycle power. Therefore, one of the major advantages of video tape over movies is somewhat offset by having to take the spool of recorder tape off the recorder to play it on another machine which is nearly as heavy as the ones used in this study.
- (2) The horizontal resolution of the battery powered systems is from 220 to 300 lines. This is a loss of 180 to 100 lines compared to the larger units.
- (3) The tape capacity allows 20 minutes of continuous recording, whereas the VTR units used in this study provide for one hour of continuous recording.
- (4) The batteries will provide for one hour of recording when fully charged.
- (5) The hand held camera requires support for lengthy recording sequences or for those scenes requiring telephoto work.

No VTR system has all of the characteristics needed for maintenance evaluation. Based on the experience gained in this study, it is recommended that both the battery powered units and the larger systems should be used in PSTB.

In order to perform PSTB properly, some of the complex tasks should be recorded simultaneously from different camera angles. For example, weapons loading involves a crew of four people who at times are widely separated. A wide angle shot would define positions but would be useless for details. A camera working on details would not show the positioning of the team.

The VTR technique is not difficult to learn. The ATC personnel and several McDonnell Douglas engineering psychologists have learned to use the technique. With the test guide and video tape instructions an average person can learn the procedures in one day, and become proficient in one week. The rapid playback of recordings speeds up the learning process and gives the trainee confidence.

The most significant problem associated with the wide utilization of the VTR technique is the variance of VTR machine characteristics from one manufacturer to another. A recording made on one machine, with a given tape size, speed, and scanning pattern will not play back on any other machine except one that has identical characteristics. There is little evidence that the industry is approaching a standard format. Standardization may take many years, and to wait for such a development would seriously delay the utilization of a valuable tool. The logical solution to the problem is for the contractors, vendors, and military services to standardize on the basis of the most versatile and best designed equipment available.

b. Lenses

(1) Assessment

The two zoom lenses used with the system worked well. The zoom feature definitely is required for adequately recording maintenance functions. Of the two lenses, the Angenieux 15-150mm focal length range was used more frequently simply because it had a 10-1 zoom ratio. The Canon lens has only a 4-1 ratio zoom ratio.

A few problems were encountered with the use of these lenses. The operator must reach around the camera while viewing the monitor and manually position the focus, zoom, and iris settings. The crank for the zoom ring on the Angenieux lens sometimes becomes inadvertently disengaged and when the operator needs to zoom he may have to spend time getting the crank and ring gear teeth engaged. This can result in loss of detail or a point of interest.

On a few occasions it would have been useful to have lenses that would produce magnified images of small parts, and lenses that had an extremely wide angle of view, to provide for recording of tasks within the equipment compartments.

(2) Recommendations

- (a) Zoom lenses with large focal length ratios should be used. The minimum ratio recommended is 8-1.
- (b) Zoom lenses should be provided with remote control of focus, zoom, and iris functions, and the controls should be located on the rear of the camera or on the tripod handle. The control box for the lens should be clearly labeled in terms of control functions to prevent slewing the wrong direction.
- (c) An extremely wide angle lens, about 5mm, should be available for work inside of compartments. Experiments should be conducted to test the feasibility of using coherent fiber optic bundles in very limited areas.
- (d) Supplementary lenses and filters should be part of the system. The supplementary lens available for some zoom lenses extends the zoom range by 1.5X or 2.0X. A f2.8, 15 to 150mm lens becomes a f4.5, 25-250mm lens with a 1.5X adapter, or a f5.6, 30-300mm lens with a 2.0X adapter. There is, of course, a penalty in light transmission.

c. Camera

(1) Assessment

The GPL camera provided very good picture quality and no malfunctions were experienced with it. However, the lack of a built-in viewfinder or

monitor on the camera was a definite handicap. The mounting of the monitor between the tripod legs tends to produce disorientation of the operator with respect to the object. Zooming and panning had to be accomplished wholly on the basis of the monitor image.

The video level meter was a valuable addition to the camera in that it provided a feedback on the target and beam control settings and assured optimum video signal to the recorder.

The improved camera mount was decidedly superior to the single bolt mounting provisions that are on the off-the-shelf equipment.

There were numerous times when it would have been desirable to point the camera down to give an overhead view. This was not done due to the risk of damaging the vidicon tube with internal debris falling from the filament onto the vidicon face. This creates white spots which are permanent.

(2) Recommendations

- (a) Any video camera used to evaluate maintenance should have a built-in viewfinder. This should be a cathode ray tube (CRT) rather than an optical device. This will provide the operator with correspondence cues between the object and movement of the camera.
- (b) All controls associated with the camera and lens should be built into the camera, attached to it, or on the tripod handle.
- (c) The camera should be provided with a video level meter to assure proper signal strength.
- (d) Camera should be lightweight and rugged.
- (e) The camera should be provided with a strong mounting bracket that gives positive locking.
- (f) Very small hand held cameras are necessary for work inside of cockpits and compartments. However, in these environments the zoom lens, CRT viewfinder, and video level meter would probably have to be sacrificed for mobility and accessibility.
- (g) Various erecting and roof prisms should be investigated to develop a vertical (downward) capability for the zoom lenses.
- (h) Various lens mounting plates should be acquired so that the camera can be placed closer to the object for very detailed work. These would merely extend the lens distance from the vidicon tube face, and would restrict the focusing of the lens at the greater distances making markings on the focus ring incorrect.



Figure 32. Viewfinder Camera with Remote Control Focus and Zooming Functions



Figure 33. Camera Section with Viewfinder Camera

- (1) Special low light level, and infrared, vidicon tubes should be investigated to determine to what extent they will perform under low scene illumination levels.

d. Cabling

(1) Assessment

The cabling and power lines were effective and significantly reduced confusion, hook-up time, and obstructions on the floor. The BNC connectors were much easier to connect and provided adequate engagement feedback. These connectors are subject to damage if stepped on, and are difficult to install on coax line without the proper tools.

Although cables lengths were adequate for most of the flight line, hangar, and shop work, it was obvious that units that have a self contained power supply could significantly reduce the weights, length, and number of wires.

(2) Recommendations

- (a) Wiring and cabling of a video tape system is very important to its mobility and capability. A VTR system should be mocked up and the wire lengths, cable combinations, and connecting points optimized early in design.
- (b) The use of auxiliary power units should be thoroughly investigated with the possibility that a VTR system can be totally self contained.
- (c) The small battery powered VTR systems should be used in situations where ground power is not available, or when very fast reaction time is required.

e. Tripod and Dolly

(1) Assessment

The tripod and dolly gave excellent service. The tripod was rigid and the height range (32" to 72") was adequate for most of the study work. As long as there is ample floor space in which to maneuver, the legs do not interfere with the task. However, if there are obstructions the only way to position the camera is to place the tripod upon an object, hand hold it, or mount the camera on some other support.

When recording munitions loading or other tasks beneath an aircraft fuselage and wings, the tripod and camera barely clear the overhead. This limit on the low adjustment also prevents the camera from looking up into the compartments where the work is being performed.

The 4-inch, hard rubber wheeled casters on the dolly are adequate for hangar floor, shop, and flight line work as long as one does not have to move over cables and air hoses. Any obstruction of this kind makes necessary the lifting the camera station over the object.

(2) Recommendations

- (a) Tripods and dollies procured for VTR should be of the heavy duty type in order to support the camera weight and to reduce vibration.
- (b) Tripod pan/tilt heads should have provisions for holding the video camera tightly and should have positive locking features.
- (c) Some tasks may require camera mounting on structures other than tripods. Various pieces of Air Force AGE can be used such as elevator work stands, cherry picker cranes, and facility structures (railings, overhead rails, and cat walks).
- (d) For low angle work, tripod accessories should be provided to allow the camera to be offset from the center. This will permit the camera to be lowered nearly to ground level.
- (e) For hangar and flight line use, the dolly wheels should be replaced with 8-inch diameter pneumatic wheels so that the dolly can be moved over moderate obstructions.

f. Microphones

(1) Assessment

The microphones produced good quality sound recordings except in areas where the ambient noise level was high.

The biggest problem with microphones is the cable. In most of the tasks, the movement of the maintenance personnel is impeded by the microphone cable getting caught on structure, tripping personnel, and either being too long or too short for the job.

The carbon microphone on the headset could not be matched with the two dynamic microphones. Consequently, the carbon microphone overloaded the audio while the other two gave weak or indistinguishable inputs. If the gain on the audio was increased so that the dynamic microphones gave an adequate recording level the carbon headset would overdrive and the voice was unintelligible.

(2) Recommendations

- (a) An investigation to determine the best microphones to use in high ambient noise environment should be made. These tests should involve noise cancelling and throat microphones.
- (b) The use of wireless microphone systems should be investigated in terms of their applicability to the VTR technique.
- (c) The use of a small portable audio tape recorder to acquire voice and later dub it on the video tape is a workable solution but requires more work.
- (d) Care must be taken to match the input characteristics of microphones so that VTR audio level will be reasonably constant.

g. Headphones

(1) Assessment

The use of a headset to monitor the audio inputs is desirable to allow the operator to control gain and microphone selection.

Originally we had tried some inexpensive plastic headphones but found that they did not shield out the ambient noise, and they became very uncomfortable within 15 to 20 minutes.

(2) Recommendations

- (a) Use only dual earphones with foam ear cushions
- (b) Provide a volume control on the set to allow operator to adjust volume without changing audio level setting.

h. Video/Audio Junction Box

(1) Assessment

The video/audio junction box was designed to meet the requirement for a common attachment for signal cables. It also served as a control for microphone selection and video live or VTR. The structure takes the load off the camera, monitor, and headset connectors. The attachment of this box to the mounting blocks was effective and easily engaged and disengaged.

(2) Recommendations

- (a) Provisions should be made for a common point of attachment of all cabling at the camera station. Additional controls can be installed in such a unit.
- (b) The video/audio junction box should be provided with quick and effective mounting provisions.

i. Monitor

(1) Assessment

The only reason for mounting a monitor on the camera station was to provide video feedback. The size of the monitor, the monitor mounting bracket, and the space they occupy creates many problems.

When the monitor is used for playback, the larger size units have a distinct advantage. The controls on the Miratel monitor were adequate.

(2) Recommendations

- (a) Use video cameras that have a built-in monitor for recording.**
- (b) Use large monitors for playback. This unit should be used in a relatively dark room, or have an adequate glare shield built onto it. A high ambient light level illuminates the phosphor on the tube face and reduces picture contrast and clarity.**

j. Video Tape Recorders

(1) Assessment

Both the Ampex Model 7000, and the Bell and Howell Model 2920 recorders were used in this study. The VTR cart was designed around the Ampex recorder as well as the cabling configuration. Both recorders performed well. The Ampex unit required replacement of tape guides (they were beginning to shred the tape).

The quality of image and sound recording was quite good. The ATC members of the PSTC quickly learned how to use both recorders. Most of the comments that are applicable to the recorder have been stated in the previous VTR system assessment and recommendations section.

Some specific disadvantages are that these units required 115V, 60 Hz ground power and they are heavy and cannot be hand-carried very far. They are not compatible except to electronically duplicate or edit from one machine to another.

A complete VTR system based on either the Ampex or Bell and Howell recorder involves many items and interconnections and is therefore not capable of immediate reaction. Five minutes is about the minimum preparation time.

(2) Recommendations

- (a) The effective utilization of the VTR technique will depend greatly upon the standardization of equipment among the Air Force commands and offices, the contractors and vendors.**

Before a large amount of incompatible VTR equipment is purchased, it is suggested that the aerospace industry and Air Force form a committee to investigate this equipment area, and formulate standards so that funds will not be expended on equipment that has limited value.

- (b) The manufacturers should be encouraged to develop equipment that is compact, versatile, and capable of working under poor lighting, high noise, and limited space conditions.

k. VTR Cart

(1) Assessment

In order to compensate for the weight and complexity of the VTR system it was necessary to develop a vehicle that would provide for operation, transportation, and stowage of the equipment. This cart contributed greatly to the effectiveness of the technique. The mobility of the system was greatly superior to that of the earlier office supply carts. The provisions for stowage and rapid access to system elements assured the operator that all items were available and permitted fast assembly.

The VTR cart is quite heavy. However, it has been pulled along flight lines and around hangars by one person. There is no doubt that the weight could be drastically reduced through the selection of materials and redesign. It is doubtful that many of the features could be eliminated, however. It should be remembered that the cart contains what amounts to a complete television and recording system. Additional pieces of equipment such as lights, light and camera tripods, and the tripod dolly should be carried on the cart.

Tractors and trucks on Air Force Bases are generally available for towing such a cart over long distances. This cart was towed 25-30 miles over the ramps and taxi ways without a mishap or damage to the stowed equipment. Since most of the hangars and shops were accessible via taxiways there was no problem of impeding traffic.

(2) Recommendations

- (a) Large VTR recorders require a means of transportation and stowage.
- (b) The tricycle wheel arrangement of the cart used in this study proved to be versatile. It is suggested that the front wheel be doubled (but not spread apart). This would reduce roll and still allow 360° steering.
- (c) The rear wheel spacing allowed the cart to negotiate narrow doorways and hallways. However, the rear wheels should be provided with a mechanism for extending them another foot on each side. This can be done with axles that can be extended by means of a screwjack. This would provide greater stability during towing.

- (d) The diameter of the wheels should be increased to 10 inches to smooth out the ride over obstructions. The tires should be pneumatic to absorb shock and to provide more clearance between the bottom of the cart and the ground.
- (e) The towing tongue should have a latch to hold it in the upright position when it is not being used.
- (f) Provisions should be made in the cart for the stowage and transportation of the tripod, dolly, and lighting equipment.
- (g) The cart should be provided with cable reels for efficient stowage and unreeling of the long power and cable reels.
- (h) A slide out or fold down work table should be incorporated into the cart to provide for paper work and minor repairs.
- (i) A means of adjusting line voltage should be provided because ground power may vary.
- (j) There should be no projections from the sides of the cart such as handles and connectors to create damage when passing through doorways.
- (k) An investigation should be made into suitable power plants that would make a cart self-sufficient and reduce cabling requirements.
- (l) The design of a VTR cart should emphasize weight reduction while maintaining sufficient structural strength.

1. Lights

(1) Assessment

In the early part of this study a series of fixtures and lamps were tested. The intensity, coverage, and lamp life were investigated. It was apparent that good lighting was the key to good detail, depth of focus, form and shape. The common floodlights, spotlights, and photofloods did not possess the proper characteristics. The readily available fixtures were weak and provided limited control. It was decided to procure professional lighting equipment. This decision was based upon discussions with VTR and TV lighting specialists. The four lights performed very well and their use made a big improvement in the quality of the recordings. The tripods were versatile but were subject to being pulled down if someone tripped on the power line.

All of the lighting equipment except for the tripods are transported and stored in two cases.

(2) Recommendations

- (a) Use professional lighting units whenever possible to provide good contrast and detail.
- (b) Tripods should be weighted with sandbags or shot bags when used in areas of heavy traffic.
- (c) The lights should be plugged into a different fuse block than the one used for the VTR system to prevent overloading the circuit.

SECTION VI

SUMMARY AND CONCLUSIONS

The video tape recording technique as configured and applied in this study should be regarded as an introduction of a PSTZ technique rather than a fully developed technique. The potential uses of the VTR technique were recognized by most of test personnel who had an opportunity to assess it. It is evident that for this technique to mature and be effectively utilized, more development and greater exposure will be necessary. Very few people (less than 5 percent) who were exposed to this technique during the study had been previously aware of the resolution that could be obtained, the ease of operation of the VTR, or the methods of application. However, most were enthusiastic about its future in the field of testing.

The use of the VTR technique will be summarized in terms of the original selection criteria.

Will Objectively Measure Human Performance

The analyses of the video tapes resulted in the identification and quantification of many aspects of human performance without requiring information from the subjects. The data included: the time to perform a task, the number of times a particular sub task was performed, a record of task difficulty based on number of unsuccessful attempts, errors and error rates, degree of dependency on T.O. procedures, degree of dependency on supervision, and frequency and type of problem solving behavior.

Provide Data That is Useful to a System Test Effort

Due to the lack of maintenance activity on the two selected subsystems, no answer is available in regard to the Category II test effort. However, use of the VTR on the AGM65A trials, F-4 Aircraft Anthropometric study, and Rockeye II bomb tests provided valuable information to the test personnel, and to design engineers and support personnel.

Can Be Used During Test Activities

The VTR equipment was used in hangar, flight line, shop and office areas. The only limitation is the availability of adequate power.

Will Produce Minimum Interference With Test Activities

The presence of the VTR equipment and the form of its data are obvious to those who are performing the tasks. There is little evidence that this knowledge interferes with the task. In a few cases where the maintenance personnel were required to move to allow the camera to record the task there was some slowing down of the task performance.

The current PSTE techniques of questionnaires and checklists consume time but seldom result in useful data. The value of direct observation and note taking is directly related to the knowledge and skill of the observer. In addition, complex tasks involve too many actions to monitor and assess in real time.

A task performed by an individual or a team will seldom be repeated in the exact way it was performed the first time. With a recording the effects of learning, and familiarization can be ruled out or identified. If one wanted to establish these effects, he could compare recordings, made after classroom training, after on-the-job training, and after six months of experience.

Have a Potential of Being Frequently Used and Applicable to Many Subsystems

The application of the VTR technique in this study has demonstrated its versatility and applicability.

Will Be Based on the Technique as Being a PSTE Tool in Contrast to a Research and Development Tool

The evidence obtained in this study indicates that the VTR technique can be used extensively in testing and research and development.

Can Be Used By Test Personnel Without Extensive Training

The Air Training Command personnel and MDC Engineering Psychologists were able to operate the VTR equipment after one day of training. Proficiency in the use of this technique to collect PSTE data requires additional knowledge but this is primarily in the area of human engineering.

Will Generate Data That is Usable by SPO's, Contractors, and the Air Force Commands

The VTR data collected in this study was used by the contractors, AFSC, ATC, and TAC. The primary deterrent to wider data utilization was the lack of playback equipment in the Air Force, contractor, and vendor facilities.

Will Be Adaptable to a Fast Reaction Situation

The modified VTR equipment could be put in operation within 5 minutes at the F-4E Category II test site. When the camera station equipment was stowed in the VTR cart, the setup time was extended to 25 minutes. The use of small battery powered VTR's would permit response to the most urgent situations.

Will Provide Results That Have Operational Significance

The VTR data collected during this study on several weapons loadings possessed operational implications. The recording of the trials involving

the R & D missile loading typify the points at which the VTR technique should be used to predict the weapons' impact on operational units.

The utilization of the VTR technique should be directed toward new system and subsystem development, and be employed during development from conceptual studies to operational use. The VTR should be regarded as a valuable new tool but not as a cure-all.

An important role for this technique is beginning to be recognized. Task analysis is the foundation for most of the PS elements. The VTR technique provides for a reproduction of tasks. Although design engineers, test engineers, and many others involved with system design and development may make little use of task analysis, it is obvious that task performance data is basic to many disciplines. Therefore, by providing a common data base in a form that can be quickly and accurately assessed, it is conceivable that design can be accelerated, problems reduced, and data for the preparation of training and T.O.'s provided earlier.

The point in time at which a task can be evaluated is important. If the task can be evaluated early through the use of mock-ups, simulations, and prototype equipment there is a good chance that problems identified before production can be rectified.

A design engineer has to deliver a functioning piece of equipment by a certain date, within a specified budget, and it must conform to weight, size, and various other physical constraints. These requirements put considerable stress upon the development stage. Those personnel who are responsible for AGE design, training, T.O.'s, personnel subsystem elements, training equipment, reliability and logistics are to a great extent dependent upon the AVE equipment design. The most valuable inputs to design are those that are clearly defined and provided in the concept stage. But, during this stage transfer of information among AVE engineering and the supporting groups is infrequent and fragmentary. The VTR technique has the capability to improve this process during system development.

The VTR technique is capable of documenting design process and equipment performance, demonstrating compliance with specifications, and reporting problems to the Air Force. One potential problem with the use of the VTR technique for reporting is the fact that contractors may generally oppose the exposure of problem areas. They may prefer to solve problems themselves without unduly alarming the customer. To a certain degree, this is a justifiable view for many of the equipment problems are solved before the first production unit is delivered. But, generally not all problems are solved. This brings up the question, "when does the customer need to be informed?" The scope, timing, and requirement for VTR data should be established in the contract for the weapon system.

The use of the VTR for PSTE should be assigned to the human factors personnel. In this study, the results from trials in which the human factors specialist directed the use of the VTR system were decidedly inferior to those in which the human factors specialist did the work himself. This judgement is based on the quality of the data on the tape.

If the VTR technique were to be fully implemented in a PS program, some method for selecting, reducing, and distributing the data would have to be developed. The VTR has an inherent feature that would permit encoding and decoding sections of the tape. The formulation of an adequate code and the design of the equipment are areas that should be investigated.

The VTR data can be transmitted over closed circuit telephone lines. AFSC presently has a network of this type. The receiving stations may record or view the data without recording. Most contractors have widely spread facilities and a similar video network could provide for rapid communication among the plants.

APPENDIX I

VIDEO TAPE RECORDING SYSTEM ASSEMBLY, OPERATION AND MAINTENANCE

INTRODUCTION

The procedures contained in this manual prepare the Video Tape Recording System from a storage or shipping configuration to an operating configuration. The procedures consist of the following sections: Reference Publications; Precautions to be Observed; Unpacking and Preparation; Turn-on and Adjustment; Operation; Shut-down; and Preventive Maintenance.

The Reference Publications section itemizes the commercial manuals that support the commercial components comprising the Video Tape Recording System.

The Precautions to be Observed section identifies various areas in the Video Tape Recording System that, under certain conditions, are subject to damage, and specifies the correct methods for avoiding the damage.

The Unpacking and Preparation section provides a parts inventory, unpacking and assembly instructions, and equipment hook-up instructions.

The Turn-on and Adjustment section provides preliminary control settings instructions, tape threading instructions, and equipment turn-on and adjustment procedures.

The Operation section contains all procedures necessary to fully utilize the Video Tape Recording System.

The Shut-down section provides instructions for partial or complete disassembly, and storage, of the Video Tape Recording System.

The Preventive Maintenance section specifies certain components of the Video Tape Recording System that require frequent attention, and provides the necessary procedures for performing maintenance on the components.

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SECTION I
REFERENCE PUBLICATIONS

1-1. GENERAL.

1-2. The following is a list of publications supporting the various commercial units that comprise part of the Video Tape Recording System:

- a. Precision 700 Television Camera, Operation and Service Instruction Manual.
- b. Video Tape Recorder, Model VR-7000, AMTEX Operating Manual.
- c. Sony Cassette-Corder, Sony-matic TC-100, Owner's Instruction Manual.

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SECTION II

PRECAUTIONS TO BE OBSERVED

2-1. GENERAL.

2-2. The following information describes certain areas in the Video Tape Recording System that are susceptible to damage, therefore requiring special attention.

2-3. TV CAMERA.

2-4. To prevent damage to the TV Camera vidicon tube, do not point the camera at the sun or sunlight reflections (glare) at any time with the lens cap removed. Ensure lens cap is installed at all times when camera is not used.

2-5. To prevent damage to the vidicon tube caused by residue in the tube, do not point the TV camera, lens down, at an angle exceeding 45 degrees from the horizontal.

2-6. To avoid possible damage to circuitry in the TV Camera due to accidental grounding, do not disconnect the video cable connected to the camera VIDEO jack while power is applied to the camera.

2-7. ILLUMINATION.

2-8. To prevent possible overloading of lines and fuses of the Video Tape Recording System, connect illumination lamps to a 115 vac 60 cycle power source separate from the system power.

SECTION III

UNPACKING AND PREPARATION

3-1. GENERAL.

3-2. Section II, Unpacking and Preparation, provides a check of the availability of all components comprising the Video Tape Recording System. The section also provides instructions for setting up the Camera Station configuration and the Video Recorder.

3-3. See Figure 3-1 for a typical set-up of the Video Tape Recording System. If video or video and audio are to be recorded, perform paragraph 3-7, Preparation For Recording and Playback. If only playback or audio dubbing is to be performed, perform paragraph 3-15, Preparation For Playback or Audio Dubbing Only.

3-4. PARTS INVENTORY.

3-5. All components and units comprising the Video Tape Recording System are shown and indexed in Figure 3-2.

3-6. Before beginning assembly of the Video Tape Recording System, check for availability of all parts per Figure 3-2.

3-7. PREPARATION FOR RECORDING AND PLAYBACK.

NOTE

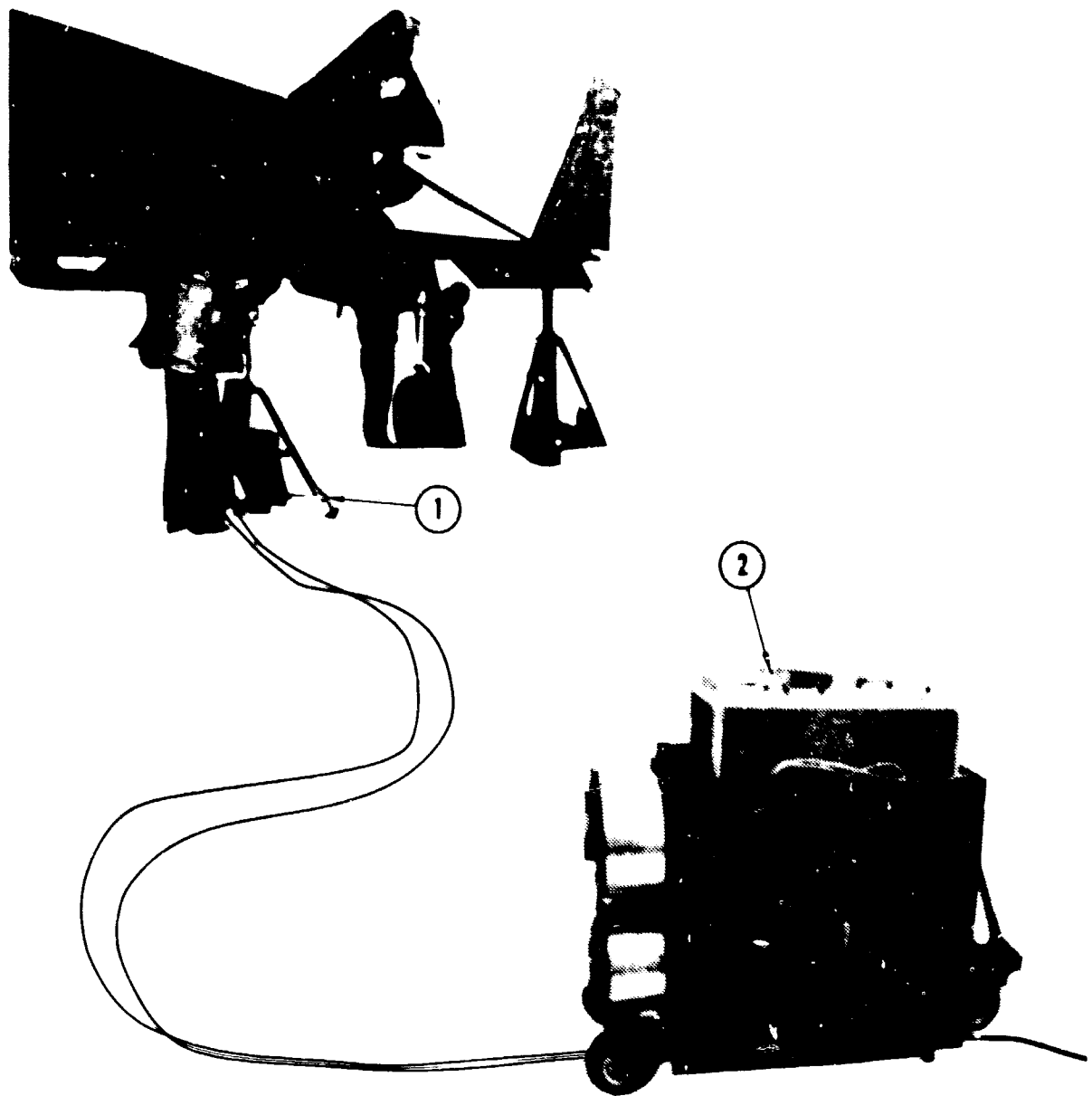
Following procedure completely assembles Video Tape Recording System for both recording and playback (if only playback or dubbing audio on video tape is desired do not perform following procedure - proceed to paragraph 3-15, Preparation for Playback or Audio Dubbing Only.)

3-8. CAMERA STATION PREPARATION.

See Figure 3-3.

3-9. Camera/Tripod.

- a. Prepare tripod dolly (2) by placing hands on spreaders (arms with wheels attached) such that spreaders will not pinch hands against center piece, and unfold spreaders. Play dolly wheels down, on floor.



- 1. CAMERA STATION
- 2. TELEVISION CART

FIGURE 3-1 VIDEO TAPE RECORDING SYSTEM

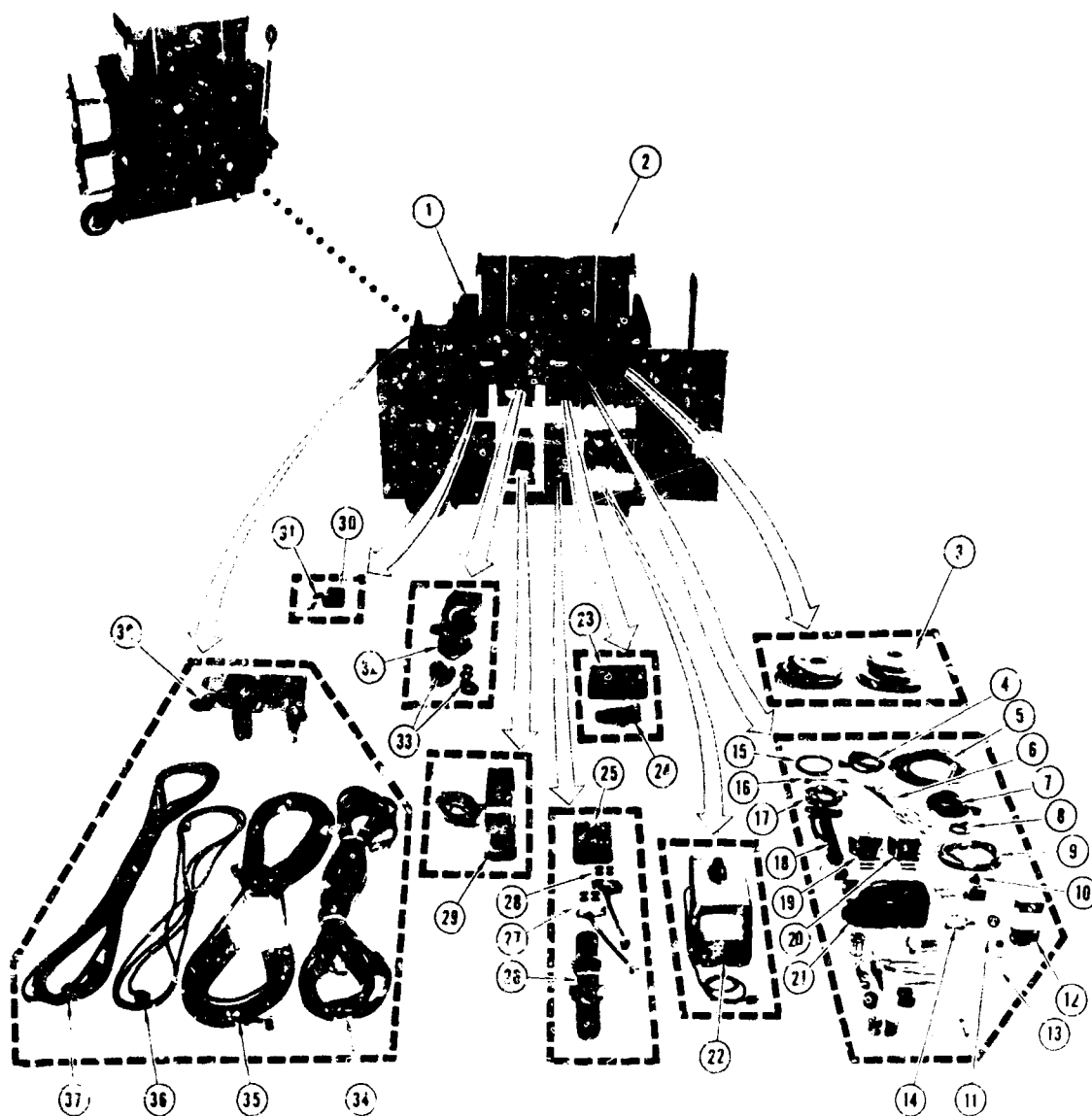


FIGURE 3-2 TELEVISION CART CONTENTS

1. TELEVISION CART
2. VIDEO TAPE RECORDER (AMPEX MODEL VR-7000)
3. TAPE REELS (5)
4. W. ELECTRICAL CABLE
5. W10 ELECTRICAL CABLE
6. W6 ELECTRICAL CABLE
7. W11 ELECTRICAL CABLE
8. W12 ELECTRICAL CABLE
9. W13 EXTENSION CABLE
10. REMOTE CONTROL UNIT
T-SCREWS (2)
11. MAGNETIC TAPE HEAD CLEANER (SPRAY) (MS-200, MILLER-STEPHENSON CHEMICAL CO., INC.)
12. ISOPROPYL ALCOHOL
13. AMPEX HEAD CLEANER (P/N 010823)
14. DEMAGNETIZER (HD-6) (ROBINS INDUSTRIES CORP.)
15. W1 ELECTRICAL CABLE
16. W2 ELECTRICAL CABLE
17. W3 ELECTRICAL CABLE
18. TIRE PUMP (NO. 1779) (BIG BOY PRODUCTS INC.)
19. MOUNTING BLOCK, SYSTEM POWER DISTRIBUTION BOX
SCREWS (2)
20. MOUNTING BLOCK, VIDEO/AUDIO JUNCTION BOX
SCREWS (2)
21. TOOL KIT
 - a. COAX CONNECTORS (4)
 - b. FLAT-HEAD SCREWDRIVER, LARGE
 - c. PHILIPS-HEAD SCREWDRIVER
 - d. ADJUSTABLE WRENCH
 - e. PLIERS
 - f. COTTON SWABS
 - g. SHORTING PLUG, VIDEO TAPE RECORDER
 - h. FLAT-HEAD SCREWDRIVER, SMALL
 - i. X-ACTO KNIFE
 - j. ALLEN WRENCH SET
 - k. TIRE PRESSURE GAUGE
 - l. POWER CABLE ADAPTERS
 - m. ELECTRICAL TAPE
 - n. SOLDERING GUN
 - o. SOLDER
22. TV MONITOR
23. LENS CONTAINER
24. CAMERA LENS
25. VIDEO/AUDIO JUNCTION BOX
26. CAMERA MOUNT
PHILIPS-HEAD SCREWS (2)
27. SYSTEM POWER DISTRIBUTION BOX
28. ILLUMINATION POWER DISTRIBUTION BOX
29. TV CAMERA (GPL PRECISION 700)
30. AUXILIARY AUDIO RECORDER (SONY-MATIC TC-100)
31. MICROPHONE, AUXILIARY AUDIO RECORDER
32. HEADSET (MT-S22A/U) (ROANWELL CORP.)
33. VIDEO RECORDER MICROPHONES (2) (MODEL 420) (SHURE BROTHERS)
34. W8 ELECTRICAL CABLE BUNDLE
35. W5 ELECTRICAL CABLE
36. W7 ELECTRICAL CABLE
37. W9 ELECTRICAL CABLE
38. ELECTRICAL CABLE RETAINER RINGS (4)

FIGURE 3-2 TELEVISION CART CONTENTS

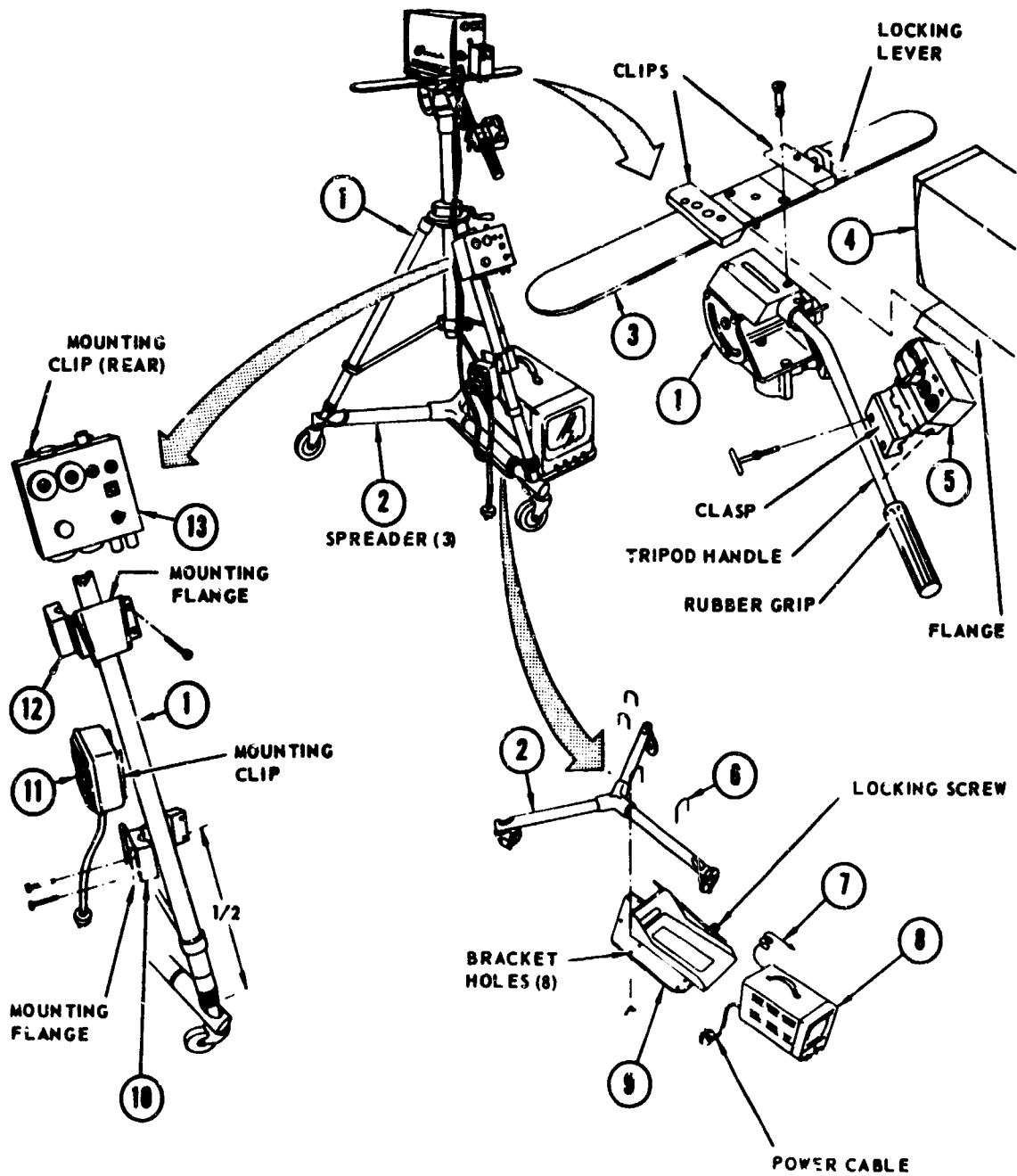


FIGURE 3-3 CAMERA STATION ASSEMBLY

1. CAMERA TRIPOD (SAMSON MODEL 7301, QUICK-SET INC.)
2. TRIPOD DOLLY (SAMSON MODEL 601, QUICK-SET INC.)
3. CAMERA MOUNT
SCREWS (PHILIPS-HEAD) (2)
4. TV CAMERA (GPL PRECISION 700)
5. REMOTE CONTROL UNIT
T-SCREWS (2)
6. U-BOLTS (4)
WINGNUTS (8)
7. W1 ELECTRICAL CABLE
8. TV MONITOR
9. MOUNTING BRACKET, TV MONITOR
10. MOUNTING BLOCK, SYSTEM POWER DISTRIBUTION BOX
SCREWS (2)
11. SYSTEM POWER DISTRIBUTION BOX
12. MOUNTING BLOCK, VIDEO/AUDIO JUNCTION BOX
SCREWS (2)
13. VIDEO/AUDIO JUNCTION BOX

FIGURE 3-3 CAMERA STATION ASSEMBLY

NOTE

Ensure mounting bracket (9) is placed under spreaders in following steps.

- b. (Two men required). Position TV Monitor mounting bracket (9) under any two spreaders on tripod dolly (2) with hinged section of bracket near center piece of dolly. Insert four U-bolts (6) over spreader arms and through bracket holes. Secure U-bolts with wing nuts and tighten.
- c. On camera tripod (1) loosen lowest knurled knob that attaches supports to center column, and separate tripod legs. If installed, remove pins from mounting holes in dolly spreaders. Adjust tripod legs and fit legs into holes on tripod dolly (2). Secure legs to dolly with pins.
- d. Remove TV Monitor (8) from storage provision in Television Cart. Ensure fan electrical plug is inserted in FAN socket at rear of TV Monitor.
- e. Set following switches on rear panel of TV Monitor to indicate positions:

<u>SWITCH</u>	<u>POSITION</u>
SYNC	INT
TERMINATE	OFF (if not last in a series of monitors) ON (if last in a series of monitors)

- f. Remove electrical cables W1, W2, W3, and W4 from storage provision in Television Cart.
- g. Connect plug P1 of electrical cable W1 (7, Figure 3-3) to one of VIDEO connectors on rear of TV Monitor (5).
- h. Ensure mounting bracket (9) is in horizontal position and locking screw on strut is secured. Position power cable and electrical cable W1 through opening in back of bracket (9), and place TV monitor on bracket. Place bungee straps over TV monitor and secure straps to bracket.
- i. Loosen bolts on mounting blocks (10) and (12) and open blocks. Position each block on tripod leg next to TV Monitor screen with wide portion of mounting flange up (place both blocks on same leg, one block positioned as high as possible with flange facing out, and other block positioned midway with flange facing left.) Tighten bolts with allen wrench.
- j. Install Video/Audio Junction Box (13) on tripod by inserting mounting clip on back of box into mounting flange on upper mounting block (12). Push box down for firm engagement.

- k. Repeat step j to install System Power Distribution Box (11) on lower mounting block (10).

NOTE

If screws require any effort to turn in following step, reverse position of camera mount.

- l. Place camera mount (3) on tripod by engaging pins and secure with two screws.

CAUTION

To prevent damage to camera vidicon tube caused by residue in tube, do not tilt camera, lens down, at any angle exceeding 45 degrees. Do not point camera at sun or sunlight reflections (glare) at any time with lens cap removed. Ensure lens cap is installed over lens.

- m. Remove TV Camera (29, Figure 3-2) from Television Cart by rotating jam nut clockwise and sliding camera off holding flange.

NOTE

Ensure camera lens and faceplate are clean. Refer to paragraph 7-7, Lens and Faceplate Cleaning.

- n. Unlock locking lever on camera mount (3, Figure 3-3) by pulling lever up. Position TV Camera (4) over mount on Camera Tripod (1) such that camera is pointing away from tripod handle. Insert flange on bottom of camera into clips on mount. Rotate locking lever up to secure camera to mount.

NOTE

If Remote Control Unit is not to be used, do not perform step o.

- o. Unscrew the screws on Remote Control Unit (5) and open clasp. Place unit close to rubber grip on tripod handle, and close clasp over handle. Tighten the screws until unit cannot rotate on handle.

NOTE

To avoid absence of television picture upon turn-on, ensure plug P1 of cable W2 is connected to VIDEO IN jack in next step.

- p. (See Figure 3-4) Connect plug P1 of electrical Cable W2 to VIDEO IN jack on TV Camera Video Level meter box. Connect plug P2 to VIDEO jack on TV Camera.
- q. Connect plug P2 of electrical cable W1 to MONITOR jack on Video/Audio Junction Box.
- r. Connect plug P1 of electrical cable W3 to VIDEO OUT jack on TV Camera Video Level meter box. Connect plug P2 to CAM jack on Video/Audio Junction Box.

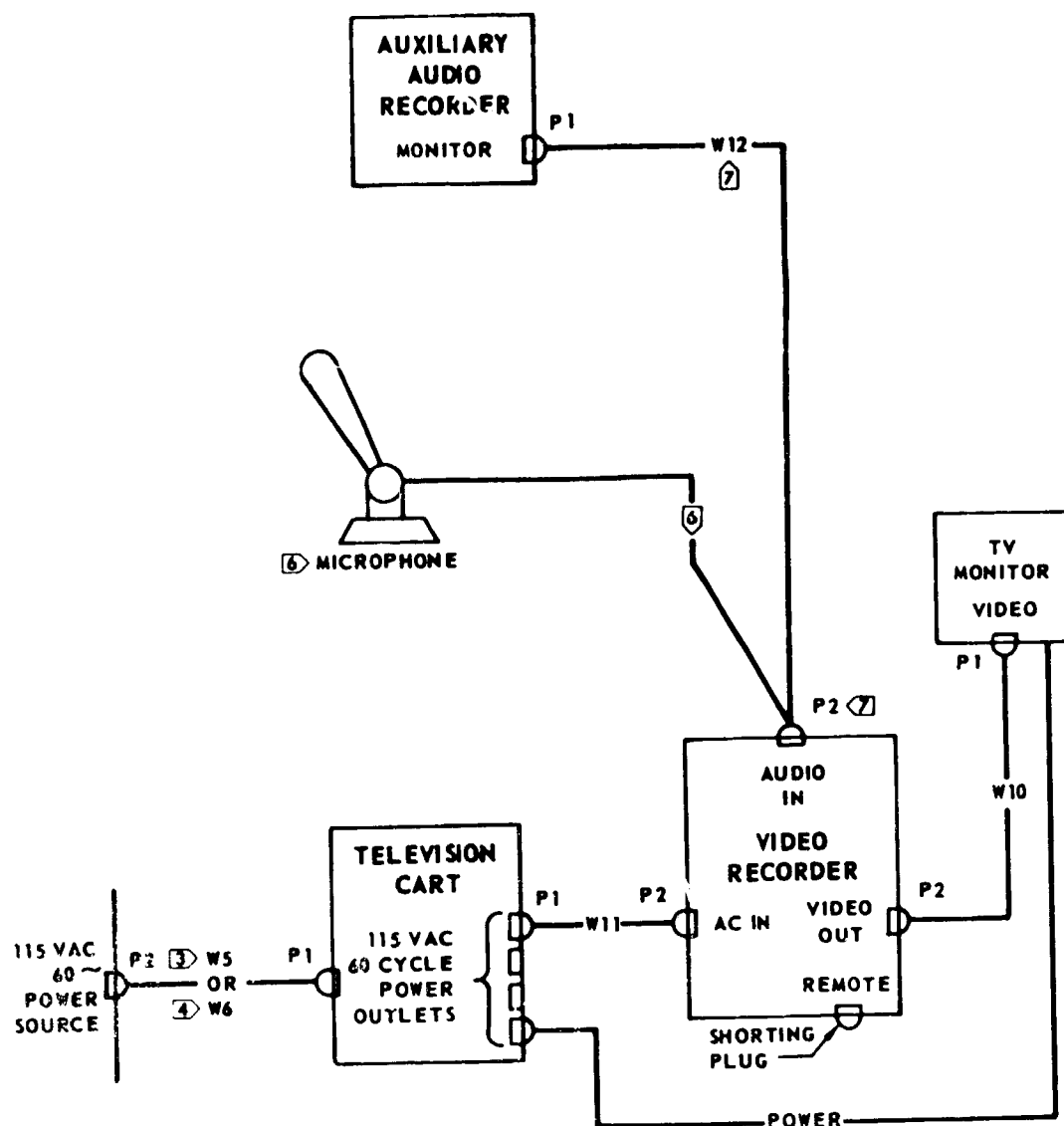
NOTE

If Remote Control Unit is not to be used, do not perform step s.

- s. Connect plug P1 of electrical cable W4 to electrical receptacle on Remote Control Unit. Connect plug P2 to REMOTE CONTROL receptacle on top of Video/Audio Junction Box.
 - t. (See Figure 3-4) Connect TV Camera and TV Monitor power cables to any ac power receptacle on System Power Distribution Box.
 - u. (See Figure 3-1) Place Camera Station near maintenance task area.
 - v. Remove camera lens (24, Figure 3-2) from lens container (23) and install on TV Camera (ensure lens cap is installed on lens).
 - w. If illumination of the scene to be televised is necessary, perform Paragraph 3-10, Illumination.
- 3-10. Illumination.

NOTE

Obtaining a high quality TV picture with the TV Camera involves effecting a compromise between the TV Camera TARGET control and lens aperture (f/number) control settings according to ambient illumination conditions. If illumination is poor, a large lens aperture (small f/number) is needed to allow more light to strike the camera vidicon tube. However, small



CABLING INTERCONNECT FOR:
 1. PLAYBACK ONLY
 2. DUBBING AUDIO ON VIDEO TAPE

NOTES

- | | |
|--|--|
| ① 75Ω TERMINATION IF LAST OR ONLY MONITOR USED | ⑩ OPTIONAL EXTENSION CABLE (MAY BE USED ON MIC 1 OR MIC 2 JACKS) |
| ② OPTIONAL | ⑪ AUXILIARY AUDIO RECORDER NOT SHOWN |
| ③ HANGAR OR FLIGHT LINE | ⑫ CONNECTED IF REMOTE CONTROL UNIT IS NOT USED |
| ④ SHOP OR OFFICE AREA | ⑬ CONNECTED IF REMOTE CONTROL UNIT IS USED |
| ⑤ OPTIONAL EXTENSION CABLE | |
| ⑥ MICROPHONE AUDIO DUBBING | |
| ⑦ AUXILIARY AUDIO RECORDER DUBBING | |

FIGURE 3-4 CABLING INTERCONNECT

f/number settings reduce depth of focus of the image. Also, the necessary TARGET control voltage output is large (clockwise rotation), which tends to cause noise (snow), lag or smearing of moving objects, and shading and corner flare.

If illumination is strong, a small lens aperture (large f/number) is necessary to decrease the light to the vidicon tube: as a result, depth of focus is increased, and the TARGET control voltage output can be decreased (counter-clockwise rotation), improving picture quality. Thus, the optimum conditions are as follows: good illumination; small lens aperture (large f/number); and TARGET control at maximum counterclockwise position consistent with picture quality.

CAUTION

To prevent possible overloading of lines and fuses of Video Tape Recording System, connect illumination lamps to 115 vac, 60 cycle power source separate from system power.

- a. Use illumination required for specific application. Generally, with an f/1.5 lens, between 10 and 30 footcandles of illumination is necessary; more if a slower lens is used.
 - b. (See Figure 3-4) To connect illumination lamps, proceed as follows: remove electrical cable W9 from reel no. 4 on Television Cart; connect jack J1 of cable W9 to ac power input cable plug at bottom of Illumination Power Distribution Box; and connect plug P2 to 115 vac, 60 cycle power source separate from system power.
 - c. Connect Illumination lamp(s) to ac power receptacle(s) on Illumination Power Distribution Box.
- 3-11. VIDEO RECORDER PREPARATION.
- 3-12. Recorder. See Figure 3-1.
- a. Place Television Cart between maintenance task area and 115 vac, 60 cycle power source.

NOTE

Do not remove large metal retainer ring from cable reel until cable is to be unreeled. (Replace retainer rings on empty reels.) To allow cable reel to rotate, pull up and rotate locking pin to either side until pin moves up into catch. If hangar or flight line maintenance task is to be recorded, use electrical cable W5 (step b). If recording occurs in shop or office area use electrical cable W6 (step c).

- b. (Hangar or flight line only) Remove retainer ring from reel no. 1 and unreel electrical cable W5.
- c. (Shop or office area only) Remove electrical cable W6 from storage provision in Television Cart.
- d. (See Figure 3-4) Connect plug P1 of electrical cable W5 or W6 to ac power input receptacle on right side of Television Cart (do not connect plug P2 to power source at this time).
- e. Remove retainer ring from reel no. 3 and unreel electrical cable W7.
- f. Connect plug P1 of electrical cable W7 to ac power receptacle on right side of Television Cart. Connect jack J2 of electrical cable W7 to ac power input cable plug at bottom of System Power Distribution Box.
- g. Remove retainer ring from reel no. 2 and remove electrical cable bundle W8.
- h. Connect plug P1 of cable bundle W8 to VIDEO OUT jack on bottom of Video/Audio Junction Box. Connect plug P2 to VIDEO IN jack, plug P3 to AUDIO IN jack, and plug P4 to AUDIO OUT jack. If Remote Control Unit is to be used, connect plug P5 to REMOTE OUT jack.

NOTE

If Remote Control Unit is not to be used and is not connected to Video Tape Recording System, install shorting plug in REMOTE jack on rear panel of Video Recorder.

- i. Connect plug P6 of cable bundle W8 to VIDEO IN jack on Video Recorder rear panel. Connect plug P7 to VIDEO OUT jack, plug P8 to AUDIO OUT jack, and plug P9 to AUDIO IN jack. If Remote Control Unit is to be used, connect plug P10 to REMOTE jack.

- j. Connect plug P1 of electrical cable W11 to Television Cart ac power receptacle. Connect plug P2 to Video Recorder AC IN receptacle on rear panel.
 - k. If illumination of maintenance task area is desired, refer to Paragraph 3-10, Illumination, for requirements and procedure.
 - l. If extra TV monitoring capability is desired, remove electrical cable W10 from storage provision in Television Cart and connect plug P1 of cable W10 to video input of extra monitor. Set Camera Station TV Monitor TERMINATE switch to OFF. Set switch on rear of extra monitor to 75 ohm impedance. Connect plug P2 of cable W10 to VIDEO connector at rear of Camera Station TV Monitor.
 - m. If audio is to be recorded while video is recorded, perform Paragraph 3-13, Headset, or Paragraph 3-14, Microphones.
- 3-13. Headset.
- a. Remove headset from storage provision in Television Cart. Set switch on headset to off position to prevent depletion of battery in Video/Audio Junction Box.
 - b. Attach headset plugs to HEADSET jacks on Video/Audio Junction Box (jacks are of different sizes and cannot be incorrectly engaged).
- 3-14. Microphones. See Figure 2-5.

NOTE

A maximum of two microphones may be used with the Video Tape Recording System, depending on need. The following procedure pertains to both microphones.

- a. Remove Video Recorder microphone from storage provision in Television Cart. Attach microphone plug to MIC 1 or MIC 2 jack on Video/Audio Junction Box. (If desired, extension cable W13 may be used to extend length of cabling between one microphone and Video/Audio Junction Box.)
- 3-15. PREPARATION FOR PLAYBACK OR AUDIO DUBBING ONLY.

NOTE

Following procedure assembles Video Tape Recording System in a compact configuration for playback only or for dubbing audio

on video tape containing previously recorded video.

TV monitor as referenced in following steps may be any available television set or Video Tape Recording System TV Monitor (removed from Camera Station).

- a. Place Television Cart and TV monitor in area equipped with 115 vac, 60 cycle power source.

NOTE

Do not remove large metal retainer ring from cable reel until cable is to be unreeled (replace retainer rings on empty reels.) To allow cable reel to rotate, pull up and rotate locking pin to either side until pin moves up into catch. If hangar or flight line area is to be used, use power cable W5 (step b). If shop or office area is to be used, use power cable W6 (step c).

- b. (Hangar or flight line only.) Remove retainer ring from reel no. 1 and unreel electrical cable W5.
- c. (Shop or office area only.) Remove electrical cable W6 from storage provision in Television Cart.
- d. (See Figure 3-4.) Connect plug P1 of electrical cable W5 or W6 to power input receptacle on right side of Television Cart (do not connect plug P2 to power source at this time).
- e. Connect plug P1 of electrical cable W11 to Television Cart ac power receptacle. Connect plug P2 to Video Recorder AC IN receptacle on rear panel.
- f. Remove electrical cable W10 from storage provision in Television Cart. Connect P1 of cable W10 to video input of TV monitor. Set switch on rear of TV monitor to 75 ohm impedance. Connect plug P2 to VIDEO OUT jack on rear panel of Video Recorder.
- g. Connect shorting plug to REMOTE jack on Video Recorder rear panel.
- h. If microphone is to be used to dub audio on tape previously used to record video, remove Video Recorder microphone from storage provision in Television Cart. Connect microphone to AUDIO IN jack on Video Recorder rear panel.

1. If Auxiliary Audio Recorder is to be used to dub audio on tape previously used to record video, remove Auxiliary Audio Recorder (30, Figure 3-2) and electrical cable W12 (8) from storage provision in Television Cart. (See Figure 3-4) Connect plug P1 of electrical cable W12 to Auxiliary Audio Recorder MONITOR jack. Connect plug P2 to Video Recorder rear panel AUDIO IN jack.

SECTION IV

TURN-ON AND ADJUSTMENT

4-1. GENERAL.

4-2. Section IV, Turn-on and Adjustment, provides location, description, and preliminary settings of various controls and indicators of the Video Tape Recording System, also preliminary adjustments and power application procedures. The section is comprised of the following procedures: Controls Preliminary Settings; and System.

4-3. The Controls Preliminary Settings procedure should be performed either wholly or in part, depending on whether a complete system or a partial (compact) system configuration is used, before any portion of the System procedure is performed.

4-4. The System procedure consists of the following: Threading Tape on Video Recorder; Application of Power to System; Camera Turn-on and Adjustment; and Video Recorder Turn-on and Adjustment.

4-5. CONTROLS PRELIMINARY SETTINGS.

CAUTION

To prevent damage to Video Tape Recording System, perform following procedures before applying power to the system.

4-6. See Figure 4-1 for operating controls and indicators (also connectors and fuses) for TV Camera, TV Monitor, Video Recorder, Video/Audio Junction Box, and Television Cart. See Figure 4-2 for description of controls and indicators (also connectors and fuses).

4-7. Set following Video Tape Recording System controls to indicated positions:

<u>CONTROL</u>	<u>POSITION</u>
TV Camera	
ON-OFF switch	OFF
BEAM control	fully ccw
TARGET control	fully ccw
FOCUS control	centered

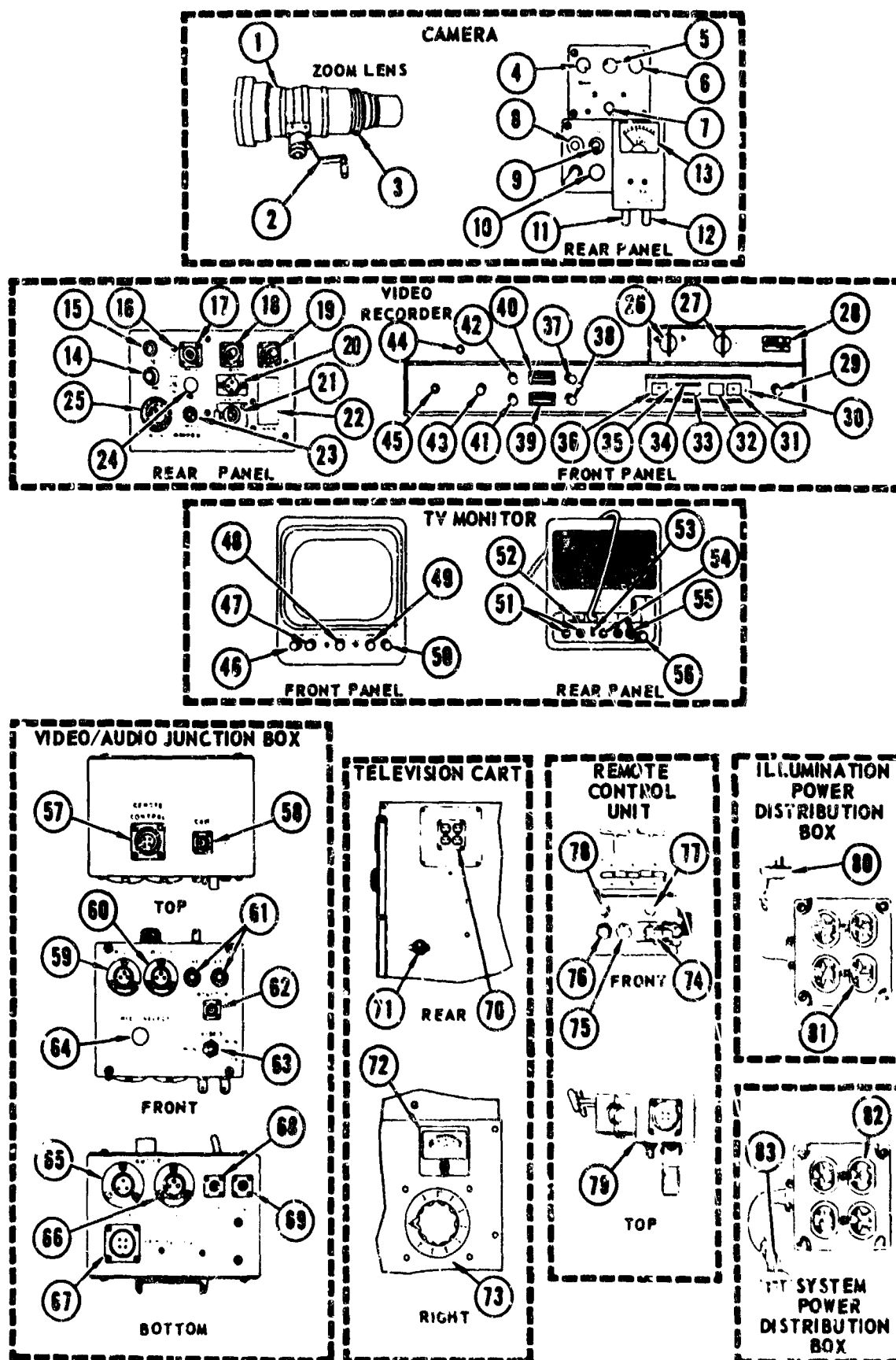


FIGURE 4-1. CONTROLS, INDICATORS, CONNECTORS AND FUSES

UNIT	INDEX NO.	CONTROL/INDICATOR/CONNECTOR/FUSE	POSITION/INDICATION	FUNCTION
TV CAMERA LENS		<u>CONTROL</u>		
	1	FOCUS	VARIABLE	FOCUSES LENS TO PRESENT SHARP IMAGE TO VIDICON TUBE.
	2	FOCAL LENGTH	VARIABLE	ADJUSTS FOCAL LENGTH FOR NEAR OR FAR SUBJECTS.
	3	APERTURE	VARIABLE	ADJUSTS APERTURE TO ALLOW SMALL OR GREATER QUANTITIES OF LIGHT TO STRIKE VIDICON TUBE.
	4	BEAM CONTROL	VARIABLE	ADJUSTS CONTROL GRID VOLTAGE ON VIDICON TUBE TO LESSEN OR INTENSIFY VIDEO IMAGE BRIGHTNESS.
	5	TARGET CONTROL	A(FULLY CCW)	ALLOWS AUTOMATIC CONTROL OF VOLTAGE SUPPLIED TO VIDICON TARGET.
			VARIABLE (FROM FULLY CCW TO FULLY CW)	ALLOWS MANUAL CONTROL OF VOLTAGE SUPPLIED TO VIDICON TARGET.
	6	FOCUS CONTROL	VARIABLE	FOCUSES VIDEO IMAGE ON VIDICON TUBE.
		<u>INDICATOR</u>		
	7	POWER LAMP	ILLUMINATED	INDICATES ON-OFF SWITCH IS SET TO "ON" AND POWER IS APPLIED TO TV CAMERA
			EXTINGUISHED	INDICATE "ON-OFF" SWITCH IS SET TO "OFF" AND POWER IS REMOVED FROM TV CAMERA
		<u>CONNECTOR</u>		
	8	VIDEO JACK		PROVIDES VIDEO SIGNAL OUTPUT
		<u>CONTROL</u>		
	9	ON-OFF SWITCH	ON	APPLIES ELECTRICAL POWER TO TV CAMERA (POWER LAMP ILLUMINATES).
			OFF	REMOVES ELECTRICAL POWER FROM TV CAMERA (POWER LAMP EXTINGUISHES)
VIDEO RECORDER REAR PANEL		<u>FUSE</u>		
	10	1/2 A SLO-BLO		PROVIDES ELECTRICAL PROTECTION TO TV CAMERA POWER SUPPLY.
		<u>CONNECTOR</u>		
	11	VIDEO IN JACK		PROVIDES VIDEO SIGNAL INPUT TO VIDEO LEVEL METER, FROM TV CAMERA
	12	VIDEO OUT JACK		PROVIDES VIDEO SIGNAL OUTPUT TO VIDEO/AUDIO JUNCTION BOX CAM JACK.
		<u>INDICATOR</u>		
	13	VIDEO LEVEL METER	0-1.0 VOLTS	INDICATES PEAK AMPLITUDE OF TV CAMERA VIDEO SIGNAL OUTPUT.
		<u>FUSE</u>		
	14	5 AMP		
	15	1 AMP SLO-BLO		

FIGURE 4-2 DESCRIPTION OF CONTROLS, INDICATORS, CONNECTORS AND FUSES

UNIT	INDEX NO.	CONTROL/INDICATOR/CONNECTOR/FUSE	POSITION/INDICATION	FUNCTION
	16	<u>CONTROL</u> CHAN ADJ CONTROL (USE SLOTTED PLASTIC TOOL)	VARIABLE	(NOT NORMALLY USED WITH VIDEO TAPE RECORDING SYSTEM) ADJUSTS CARRIER FREQUENCY OF MODULATOR OUT JACK FOR CHANNELS 2 THROUGH 5 ON TV MONITOR.
	17	<u>CONNECTOR</u> MODULATOR OUT JACK		(NOT NORMALLY USED WITH VIDEO TAPE RECORDING SYSTEM) CONNECTS TO TV MONITOR ANTENNA TERMINALS. PROVIDES 30 MV FOR TV MONITOR CHANNELS 2 THROUGH 5.
	18	VIDEO IN JACK		ACCEPTS VIDEO SIGNALS FOR RECORDING, FROM VIDEO/AUDIO JUNCTION BOX VIDEO OUT JACK.
	19	VIDEO OUT JACK		PROVIDES RECORDED VIDEO SIGNALS FOR PLAYBACK, TO VIDEO/AUDIO JUNCTION BOX VIDEO IN JACK (OR TO TV MONITOR DURING PLAYBACK ONLY OR AUDIO DUBBING)
	20	AUDIO OUT JACK		PROVIDES RECORDED AUDIO SIGNALS FOR PLAYBACK, TO VIDEO/AUDIO JUNCTION BOX AUDIO IN JACK
	21	AUDIO IN JACK		ACCEPTS AUDIO SIGNALS FOR RECORDING, FROM VIDEO/AUDIO JUNCTION BOX.
	22	REMOTE JACK		PROVIDES CONNECTION TO REMOTE JACK ON VIDEO/AUDIO JUNCTION BOX. IF ONLY PLAYBACK OR AUDIO DUBBING IS PERFORMED, A SHORTING PLUG IS INSTALLED. IF ELECTRICAL PLUG OR SHORTING PLUG IS NOT INSTALLED, FRONT PANEL SWITCHES (PUSH BUTTONS) WILL NOT FUNCTION.
	23	SPEAKER JACK		(NOT NORMALLY USED WITH VIDEO TAPE RECORDING SYSTEM) CONNECTS TO EXTERNAL SPEAKERS. OUTPUT IS CONTROLLED BY AUDIO OUTPUT SELECTOR SWITCH (INDEX NO. 24)
	24	<u>CONTROL</u> AUDIO OUTPUT SELECTOR SWITCH	SPKR	VIDEO RECORDER INTERNAL SPEAKER ONLY.
			LINE & SPKR	(NOT NORMALLY USED WITH VIDEO TAPE RECORDING SYSTEM) EXTERNAL SPEAKER WITH 600 OHM BALANCED OR UNBALANCED LINE, AND INTERNAL SPEAKER.
			LINE	(NOT NORMALLY USED WITH VIDEO TAPE RECORDING SYSTEM) EXTERNAL SPEAKER WITH 600 OHM BALANCED OR UNBALANCED LINE. INTERNAL SPEAKER IS DISABLED.
	25	<u>CONNECTOR</u> AC - IN RECEPTACLE		115 VAC 60 CYCLE INPUT POWER RECEPTACLE.

FIGURE 4-2 DESCRIPTION OF CONTROLS, INDICATORS, CONNECTORS AND FUSES (Continued)

UNIT	INDEX NO.	CONTROL INDICATOR/ CONNECTOR/FUSE	POSITION INDICATION	FUNCTION
VIDEO RECORDER FRONT PANEL	26	<u>CONTROL</u> REWIND - STOP - FORWARD SWITCH	REWIND	VIDEO RECORDER RAPIDLY REWINDS TAPE FROM RIGHT TO LEFT, TOWARD BEGINNING OF TAPE. SWITCH MUST BE SET TO STOP TO HALT REWIND. (S STOP SWITCH IS NOT EFFECTIVE)
			STOP	HALTS REWIND OR FORWARD MODES. SWITCH MUST BE SET TO STOP BEFORE RECORDING OR PLAYBACK IS POSSIBLE.
			FORWARD	RECORDER RAPIDLY MOVES TAPE FROM LEFT TO RIGHT, TOWARD FINISH OF TAPE. SWITCH MUST BE SET TO STOP TO HALT FORWARD MODE (S STOP SWITCH IS NOT EFFECTIVE).
	27	READY-THREAD	READY	ALLOWS NORMAL OPERATION OF VIDEO RECORDER.
			THREAD	EXTRACTS TAPE GUIDE FROM HEAD DRUM TO ALLOW THREADING OF TAPE. VIDEO RECORDER WILL NOT OPERATE.
	28	<u>INDICATOR</u> COUNTER	(THREE-DIGIT)	PROVIDES COUNTER READING/TIME INDICATION (SEE FIGURE 5-1 FOR TABLE) DURING RECORDING, FLAYBACK, FORWARD AND REWIND MODES, AND PROVIDES TAPE LOCATION INDEXING OF SPECIFIC RECORDED INFORMATION.
		<u>CONTROL</u> POWER SWITCH	OFF ON	REMOVES POWER FROM VIDEO RECORDER APPLIES POWER TO VIDEO RECORDER
	30	<u>INDICATOR</u> PILOT LAMP	ILLUMINATED EXTINGUISHED	INDICATES POWER SWITCH IS SET TO "ON" INDICATES POWER SWITCH IS SET TO "OFF"
	31	<u>CONTROL</u> S STOP SWITCH	PRESS TO ACTIVATE	STOPS VIDEO RECORDER FROM RECORDING OR PLAYBACK (DOES NOT STOP RECORDER WHEN REWIND-STOP-FORWARD SWITCH IS IN REWIND OR FORWARD POSITIONS)
	32	P PLAY SWITCH	PRESS TO ACTIVATE	INITIATES PLAYBACK OF RECORDED VIDEO AND OR AUDIO (AUDIO AND VIDEO LEVERS MUST BE SET TO PLAY)
	33	VIDEO LEVER	RECORD	(AUDIO LEVER AUTOMATICALLY GOES TO RECORD) ALLOWS ACTUATION OF R RECORD SWITCH FOR INITIATION OF VIDEO OR VIDEO AUDIO RECORDING (VIDEO LEVER MUST BE SET TO PLAY DURING DUBBING OF AUDIO ONLY)
			PLAY	(1) ALLOWS ACTUATION OF P PLAY SWITCH FOR AUDIO AND OR VIDEO PLAYBACK (AUDIO LEVER MUST BE SET TO PLAY) (2) PREVENTS ERASING OF VIDEO INFORMATION DURING DUBBING OF AUDIO ONLY.

FIGURE 4-2 DESCRIPTION OF CONTROLS, INDICATORS, CONNECTORS AND FUSES (Continued)

UNIT	INDEX NO.	CONTROL/INDICATOR/CONNECTOR/FUSE	POSITION/INDICATION	FUNCTION
	34	AUDIO LEVER	RECORD PLAY	ALLOWS ACTUATION OF R RECORD SWITCH FOR INITIATION OF RECORDING AUDIO ONLY. (VIDEO LEVER MUST ALSO BE SET TO PLAY) ALLOWS ACTUATION OF P PLAY SWITCH FOR AUDIO AND VIDEO PLAYBACK.
	35	<u>INDICATOR</u> RECORD LAMP	ILLUMINATED EXTINGUISHED	VIDEO RECORDER IS IN RECORD MODE (VIDEO LEVER AND AUDIO LEVER, OR AUDIO LEVER ONLY, ARE SET TO RECORD). VIDEO RECORDER IS NOT IN RECORD MODE.
	36	<u>CONTROL</u> R RECORD SWITCH	PRESS TO ACTUATE	INITIATES RECORDING VIDEO AND AUDIO IF VIDEO LEVER IS SET TO RECORD, OR AUDIO ONLY IF AUDIO LEVER IS SET TO RECORD.
	37	AUDIO OUTPUT LEVEL CONTROL	VARIABLE	ADJUSTS AUDIO OUTPUT FOR INTERNAL SPEAKER, EXTERNAL SPEAKER, OR HEADPHONE.
	38	TRACKING CONTROL	VARIABLE	ADJUSTS FOR STABLE PICTURE, DURING PLAYBACK ONLY, OBTAINING A MAXIMUM INDICATION ON VIDEO METER (SWITCH IS INOPERATIVE DURING RECORDING).
	39	<u>INDICATOR</u> VIDEO METER	0 TO 100%	INDICATES VIDEO LEVEL (100% ON WHITE PICTURES) DURING RECORDING WHEN TRACKING AND RECORD LEVEL VIDEO CONTROLS ARE PROPERLY ADJUSTED.
	40	AUDIO METER	0 TO 100%	INDICATES 100% ON PEAK AUDIO LEVELS WHEN RECORD LEVEL AUDIO CONTROL IS PROPERLY ADJUSTED.
	41	<u>CONTROL</u> RECORD LEVEL VIDEO CONTROL	VARIABLE	ADJUSTS VIDEO LEVEL DURING RECORDING TO OBTAIN 100% INDICATION ON VIDEO METER.
	42	RECORD LEVEL AUDIO CONTROL	VARIABLE	ADJUSTS AUDIO LEVEL DURING RECORDING TO OBTAIN 100% INDICATION ON AUDIO METER.
	43	AUDIO INPUT SWITCH	MICROPHONE BALANCED LINE UNBALANCED LINE	ALLOWS RECORDING OF AUDIO DURING RECORDING OF VIDEO, OR AUDIO DUBBING ON TAPE CONTAINING PREVIOUSLY RECORDED VIDEO, USING MICROPHONE CONNECTED TO AUDIO IN JACK ON REAR PANEL. ALLOWS USE OF PROPERLY TERMINATED INPUT INTO VIDEO RECORDER. ALLOWS USE OF IMPROPERLY TERMINATED INPUT INTO VIDEO RECORDER.
	44	TENSION CONTROL	VARIABLE	ADJUSTS HOLDBACK TENSION, DURING PLAYBACK ONLY, FOR MINIMUM PULLING OF LEFT OR RIGHT TOP OF ROSTER VIEWED ON TV MONITOR.
	45	<u>CONNECTOR</u> HEADPHONE JACK		ALLOWS MONITORING OF AUDIO INPUT INTO VIDEO RECORDER TO CHECK FOR UNWANTED ACOUSTIC FEEDBACK.

FIGURE 4-2 DESCRIPTION OF CONTROLS, INDICATORS, CONNECTORS AND FUSES (Continued)

UNIT	INDEX NO.	CONTROL INDICATOR/ CONNECTOR FUSE	POSITION/ INDICATION	FUNCTION
TV MONITOR FRONT PANEL	46	<u>CONTROL</u> H HOLD	VARIABLE	ADJUSTS TV PICTURE HORIZONTAL POSITION.
	47	FOCUS	VARIABLE	FOCUSES PICTURE TUBE ELECTRON BEAM.
	48	CONTRAST (OFF-ON)	OFF (FULLY CCW)	REMOVES POWER FROM TV MONITOR
			ON (ROTATE CW)	APPLIES POWER TO TV MONITOR
			CONTRAST (VARIABLE FROM FULLY CCW TO FULLY CW)	VARIABLES TV PICTURE CONTRAST.
	49	BRIGHT	VARIABLE	VARIABLES TV PICTURE BRIGHTNESS
TV MONITOR REAR PANEL	50	V HOLD	VARIABLE	ADJUSTS TV PICTURE VERTICAL POSITION.
		<u>CONNECTOR</u>		
	51	VIDEO (LEFT OR RIGHT)		ACCEPTS VIDEO SIGNAL INPUT FROM VIDEO/AUDIO JUNCTION BOX.
	52	<u>CONTROL</u> TERMINATE	ON (LEFT)	APPLIES 75 OHM TERMINATION TO VIDEO INPUT LINE
			OFF (RIGHT)	REMOVES 75 OHM TERMINATION FROM VIDEO INPUT LINE.
	53	SYNC	EXT	(NOT NORMALLY USED WITH VIDEO TAPE RECORDING SYSTEM) ALLOWS EXTERNAL SYNCHRONIZATION PULSES TO CONTROL TV PRESENTATION ON TV MONITOR
			INT	ALLOWS TV MONITOR INTERNAL SYNCHRONIZATION PULSES TO CONTROL TV PRESENTATION.
	54	<u>CONNECTOR</u> SYNC		(NOT NORMALLY USED WITH VIDEO TAPE RECORDING SYSTEM) ACCEPTS EXTERNAL SYNCHRONIZATION PULSES.
	55	FAN		(NORMALLY CONNECTED) 115 VAC 60 CYCLE POWER TO COOLING FAN.
	56	<u>FUSE</u> LINE FUSE 3 AMP		PROVIDES ELECTRICAL PROTECTION TO TV MONITOR POWER SUPPLY.
VIDEO AUDIO JUNCTION BOX TOP	57	<u>CONNECTOR</u> REMOTE CONTROL RECEPTACLE		ACCEPTS CONTROL SIGNALS FROM REMOTE CONTROL UNIT R, S AND P SWITCHES. SIGNALS ARE THEN PASSED TO VIDEO RECORDER REMOTE JACK.
	58	CAM JACK		ACCEPTS VIDEO SIGNAL FROM VIDEO OUT JACK ON TV CAMERA VIDEO LEVEL METER BOX
VIDEO AUDIO JUNCTION BOX FRONT	59	MIC 1 JACK		ACCEPTS AUDIO FROM MICROPHONE DURING VIDEO AUDIO RECORDING (MIC SELECT SWITCH MUST BE SET TO MIC 1)

FIGURE 4-2 DESCRIPTION OF CONTROLS, INDICATORS, CONNECTORS AND FUSES (Continued)

UNIT	INDEX NO.	CONTROL/INDICATOR/CONNECTOR/FUSE	POSITION/INDICATION	FUNCTION
VIDEO/AUDIO JUNCTION BOX BOTTOM	60	MIC 2 JACK		ACCEPTS AUDIO FROM MICROPHONE DURING VIDEO/AUDIO RECORDING (MIC SELECT SWITCH MUST BE SET TO MIC 2)
	61	HEADSET JACKS (2)		ACCEPTS AUDIO FROM MICROPHONE ON HEADSET DURING VIDEO/AUDIO RECORDING (MIC SELECT SWITCH MUST BE SET TO HEADSET).
	62	MONITOR JACK		PROVIDES VIDEO SIGNAL FROM TV CAMERA OR VIDEO RECORDER TO TV MONITOR (OUTPUT DEPENDS ON SETTING OF VIDEO SWITCH. SEE INDEX NO. 63).
	63	<u>CONTROL</u> VIDEO SWITCH	MON	DURING TV CAMERA ADJUSTMENT, PASSES VIDEO SIGNAL FROM CAMERA TO TV MONITOR ONLY.
			MON & VTR	(1) DURING RECORDING OF VIDEO, PASSES VIDEO SIGNAL FROM TV CAMERA TO TV MONITOR AND VIDEO RECORDER. (2) DURING PLAYBACK OF RECORDED VIDEO, PASSES VIDEO SIGNAL FROM VIDEO RECORDER TO TV MONITOR.
	64	MIC SELECT SWITCH	MIC 1	SELECTS MIC 1 JACK FOR AUDIO INPUT TO VIDEO RECORDER.
			MIC 2	SELECTS MIC 2 JACK FOR AUDIO INPUT TO VIDEO RECORDER.
			HEADSET	SELECTS HEADSET JACKS FOR AUDIO INPUT TO VIDEO RECORDER.
	65	<u>CONNECTOR</u> AUDIO OUT JACK		PROVIDES AUDIO OUTPUT SIGNALS FROM MICROPHONES OR HEADSET TO AUDIO IN JACK ON VIDEO RECORDER.
				ACCEPTS AUDIO OUTPUT SIGNAL FROM VIDEO RECORDER AND PASSES SIGNAL TO HEADSET EARPHONES.
				PROVIDES CONTROL SIGNALS, FROM REMOTE CONTROL UNIT R.S. AND P. SWITCHES, TO REMOTE JACK ON VIDEO RECORDER.
				PROVIDES VIDEO SIGNALS FROM TV CAMERA TO VIDEO RECORDER VIDEO IN JACK.
				ACCEPTS RECORDED VIDEO SIGNALS FOR PLAYBACK FROM VIDEO RECORDER TO TV MONITOR.
TELEVISION CART REAR	70	115 VAC 60 CYCLE POWER RECEPTACLES (4)		PROVIDE CORRECTED POWER OUTPUT TO EXTRA TV MONITOR, POWER DISTRIBUTION BOX AND VIDEO RECORDER
	71	115 VAC 60 CYCLE POWER INPUT RECEPTACLE		PROVIDES POWER CONNECTION OF SYSTEM TO EXTERNAL POWER SOURCE
TV CART RIGHT SIDE	72	<u>INDICATOR</u> VOLTS METER	115 VOLTS VARIABLE 0-150 VOLTS	INDICATES POWERSTAT CONTROL. SEE INDEX NO. 73. IS CORRECTLY POSITIONED FOR 115 VAC 60 CYCLE POWER OUTPUT.

FIGURE 4-2 DESCRIPTION OF CONTROLS, INDICATORS, CONNECTORS AND FUSES (Continued)

UNIT	INDEX NO.	CONTROL INDICATOR CONNECTOR FUSE	POSITION INDICATION	FUNCTION
REMOTE CONTROL UNIT FRONT	73	<u>CONTROL</u> POWER STAT CONTROL	VARIABLE	ADJUSTS INPUT 115 VAC 60 CYCLE POWER TO CORRECT FOR FLUCTUATION. CORRECTED OUTPUT IS INDICATED ON VOLTS METER AND APPLIED TO 115 VAC 60 CYCLE POWER RECEPTACLES (4) ON TELEVISION CART.
	74	R SWITCH	PRESS TO ACTUATE	INITIATES RECORDING VIDEO AND AUDIO IF VIDEO RECORDER VIDEO LEVER IS SET TO RECORD, OR AUDIO ONLY IF RECORDER AUDIO LEVER IS SET TO RECORD.
	75	S SWITCH	PRESS TO ACTUATE	STOPS VIDEO RECORDER FROM RECORDING OR PLAYBACK (DOES NOT STOP RECORDER WHEN RECORDER REWIND-STOP-FORWARD SWITCH IS IN REWIND OR FORWARD POSITION)
	76	P SWITCH	PRESS TO ACTUATE	INITIATES PLAYBACK OF RECORDED VIDEO AND OR AUDIO (VIDEO RECORDER AUDIO AND VIDEO LEVERS MUST BE SET TO PLAY).
	77	<u>INDICATOR</u> R LAMP (RED)	ILLUMINATED	INDICATES R SWITCH IS ACTUATED AND VIDEO RECORDER IS RECORDING.
			EXTINGUISHED	INDICATES R SWITCH IS NOT ACTUATED OR VIDEO RECORDER IS NOT RECORDING.
	78	P LAMP (WHITE)	ILLUMINATED	INDICATES P SWITCH IS ACTUATED AND VIDEO RECORDER IS IN PLAYBACK MODE.
			EXTINGUISHED	INDICATES P SWITCH IS NOT ACTUATED OR VIDEO RECORDER IS NOT IN PLAYBACK MODE.
REMOTE CONTROL UNIT TOP	79	<u>CONNECTOR</u> ELECTRICAL RECEPTACLE		PROVIDES REMOTE CONTROL SIGNALS TO VIDEO AUDIO JUNCTION BOX, WHICH ROUTES SIGNALS TO VIDEO RECORDER.
ILLUMINATION POWER DISTRIBUTION BOX	80	115 VAC 60 CYCLE POWER RECEPTACLES (4)		PROVIDE POWER OUTPUT TO ILLUMINATION LAMP(S)
	81	115 VAC 60 CYCLE POWER INPUT CABLE AND PLUG		PROVIDES POWER CONNECTION TO 115 VAC 60 CYCLE POWER SOURCE.
SYSTEM POWER DISTRIBUTION BOX	82	115 VAC 60 CYCLE POWER RECEPTACLES (4)		PROVIDE POWER OUTPUT TO TV MONITOR AND TV CAMERA
	83	115 VAC 60 CYCLE POWER INPUT CABLE AND PLUG		PROVIDES POWER CONNECTION TO TELEVISION CART.

FIGURE 4-2 DESCRIPTION OF CONTROLS, INDICATORS, CONNECTORS AND FUSES (Continued)

<u>CONTROL</u>	<u>POSITION</u>
Video Recorder	
(Rear Panel)	
Audio Output Selector switch	SPKR
(Front Panel)	
REWIND-STOP-FORWARD switch	STOP
READY-THREAD switch	READY
POWER switch	OFF
VIDEO lever	PLAY
AUDIO lever	PLAY
AUDIO OUTPUT LEVEL control	fully ccw
TRACKING control	fully ccw
RECORD LEVEL VIDEO control	fully ccw
RECORD LEVEL AUDIO control	fully ccw
AUDIO INPUT switch	MICROPHONE
TENSION control	(Do not adjust) Adjust during playback only
TV Monitor	
(Front Panel)	
CONTRAST (OFF-ON) control	OFF (fully ccw)
BRIGHT control	fully ccw

CONTROLPOSITION

TV Monitor (Continued)

(Rear Panel)

TERMINATE switch	OFF (if not last in series of monitors)
------------------	---

	ON (if only monitor, or last in a series of monitors)
--	---

SYNC switch	INT
-------------	-----

Video/Audio Junction Box

VIDEO switch	MON
--------------	-----

MIC SELECT switch	HEADSET
-------------------	---------

Television Cart

POWERSTAT control	fully ccw (0)
-------------------	---------------

4-8. SYSTEM.4-9. THREADING TAPE ON VIDEO RECORDER.

See Figure 4-3.

NOTE

Tape width is one inch and length is 3000 feet. The tape is normally supplied on a 9-3/4 inch diameter supply reel (left position on Video Recorder) with the oxide side facing in. During operation the tape is wound on a take-up reel (right position on Video Recorder) with the oxide side facing out. Before threading tape on Video Recorder, ensure recorder heads are demagnetized per Paragraph 7-4, Heads Demagnetizing. Ensure recorder heads and guides are clean per Paragraph 7-5, Heads and Guides Cleaning. The demagnetizing and cleaning procedures should be repeated for every eight hours of Video Recorder operation.

- a. Set Video Recorder READY-THREAD switch to THREAD (switch is normally tight through first few degrees of rotation.)

RESULT: Guide arms (9) and (10) extract from beneath head drum cover.

- b. Install supply reel (1) on left wheel hub, such that tape will unwind in a counterclockwise direction. Install empty take-up reel (7) on right wheel hub. Ensure both reels are firmly seated (rotate reels until reels drop into guides).
- c. Manually unwind three or four feet of video tape (2) from supply reel (1).

CAUTION

To prevent damage to Video Recorder, ensure retainer tape (orange) is not adhered to video tape.

- d. Place video tape (2) outside of tension mechanism roller (3), following white guide line, then on inside of tape guide roller (4).
- e. Pull tape around lower outside of capstan (5), on outside of tape guide (8), on inside of guide arm (9), then on lower right side of head drum (11).

CAUTION

To prevent tearing video tape during operation, ensure tape is not over set screw (10) on rear of head drum (11) during following step.

- f. Wrap tape counterclockwise around head drum (11). Place tape on inside of guide arm (12) and guide tape around upper portion of capstan (5). There should now be two heights of tape on the capstan.
- g. Lay tape flat against upper portion of take-up reel (7) and manually rotate wheel clockwise two revolutions until tape is taut.
- h. Manually rotate supply reel (1) until tape is taut.

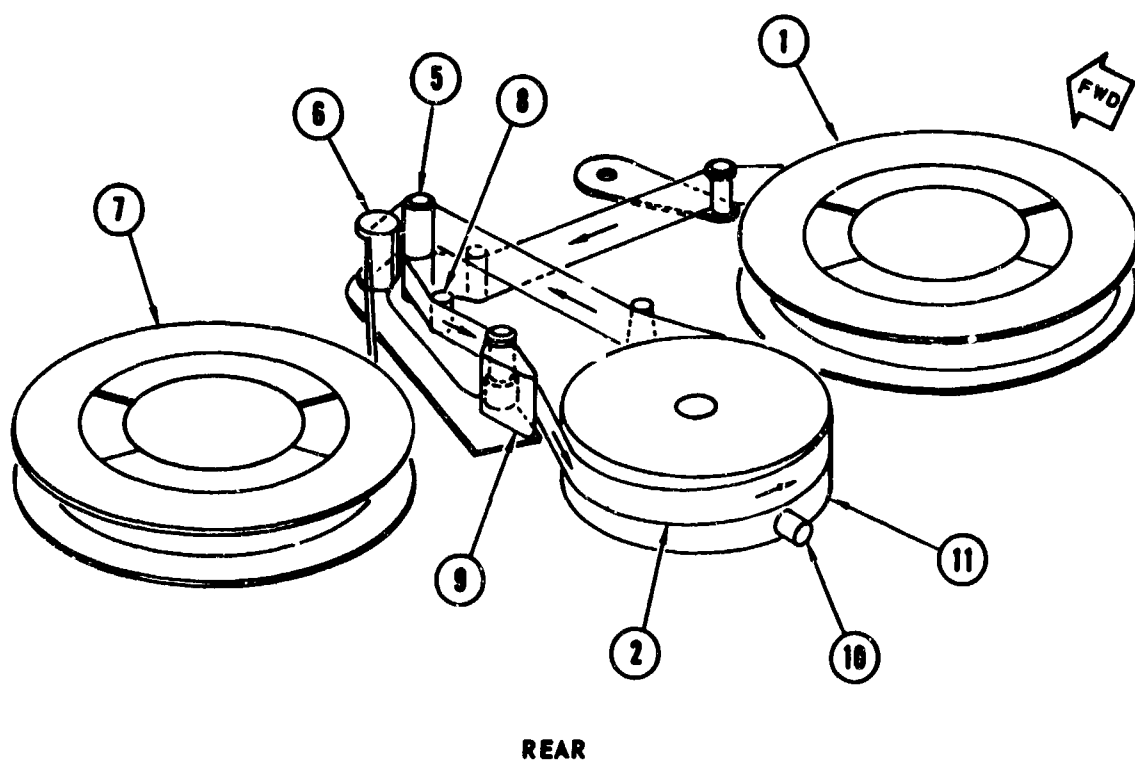
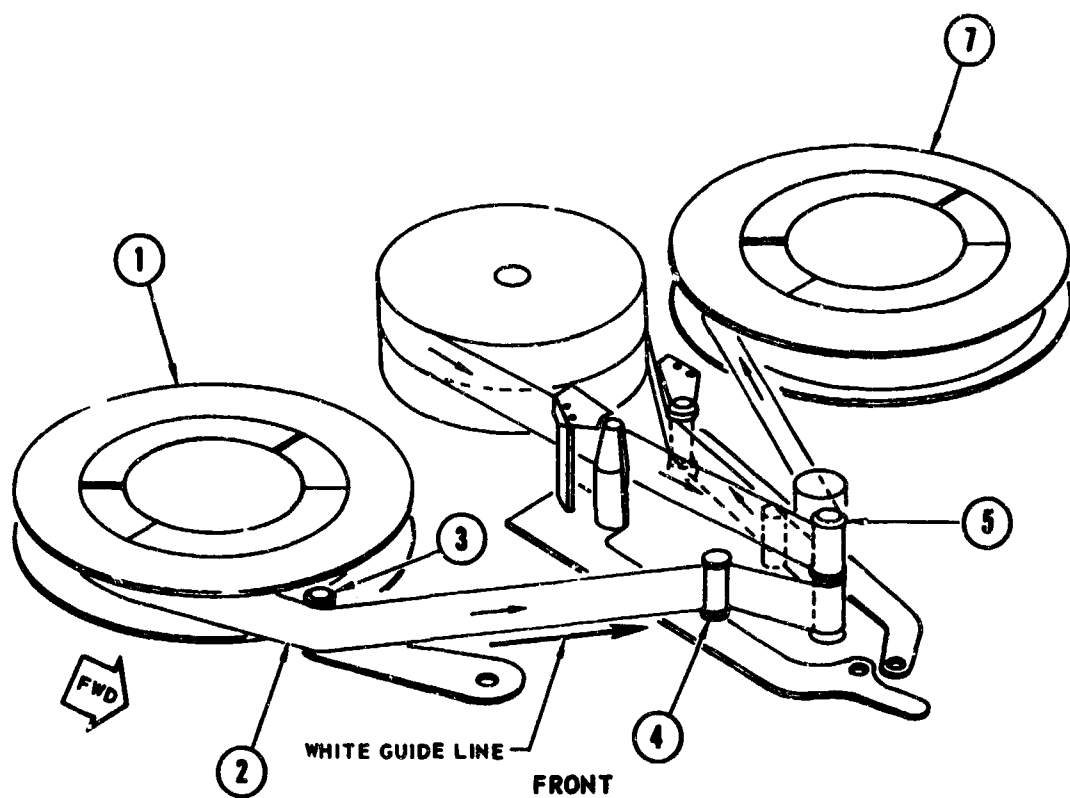


FIGURE 4-3 THREADING TAPE ON VIDEO RECORDER

1. SUPPLY REEL (LEFT)
2. VIDEO TAPE
3. TENSION MECHANISM ROLLER
4. TAPE GUIDE ROLLER
5. CAPSTAN
6. TAPE GUIDE
7. TAKE-UP REEL (RIGHT)
8. TAPE GUIDE
9. GUIDE ARM
10. SET SCREW
11. HEAD DRUM
12. GUIDE ARM

FIGURE 4-3 THREADING TAPE ON VIDEO RECORDER

4-10. APPLICATION OF POWER TO SYSTEM.

CAUTION

To prevent damage to Video Tape Recording System, ensure all switches and controls are positioned as given in Paragraph 4-5, Controls Preliminary Settings. Ensure system is properly assembled and various cables are correctly attached as given in Section III, Unpacking and Preparation. Before connecting Television Cart electrical cable W5 or W6 to external 115 vac 60 cycle power source, use voltmeter to check that voltage is correct. Do not connect to source if voltage is incorrect.

- a. Connect plug P2 of electrical cable W5 or W6 to 115 vac 60 cycle power source.

NOTE

Readjust POWERSTAT control as given in following step each time a unit of the Video Tape Recording System is turned on.

- b. Adjust POWERSTAT control on right side of Television Cart until VOLTS meter indicates 115 vac.

4-11. CAMERA TURN-ON AND ADJUSTMENT.

NOTE

Do not perform Camera Turn-On and Adjustment if Video Tape Recording System is to be used for playback or audio dubbing only.

- a. Ensure TV camera is properly aligned per Section I, Reference Publications, publication a.
- b. Arrange illumination of maintenance task area to be televised. Refer to Paragraph 3-10, Illumination. Apply power to illumination lamps.

CAUTION

To prevent damage to vidicon tube in TV Camera upon application of power, ensure camera ON-OFF switch is set to OFF and BEAM control is fully ccw. To avoid possible damage to circuitry in TV Camera due

to accidental grounding, do not disconnect video cable connected to VIDEO jack on camera while power is applied to camera. To prevent damage to TV Camera vidicon tube caused by residue in tube, do not tilt camera, lens down, at an angle exceeding 45 degrees. Do not point TV Camera at sun or sunlight reflections (glare) at any time with lens cap removed.

- c. Remove lens cap from camera lens on TV Camera. Point camera at test pattern.
- d. Set TV Camera ON-OFF switch to ON, and perform steps e through g during 10-minute camera warm-up period.
- e. Set TV Monitor CONTRAST control cw just enough to apply power to monitor.
- f. Adjust TV Monitor BRIGHT control until raster is just visible.
- g. Adjust TV Monitor CONTRAST control clockwise to center position.
- h. After 10-minute warm-up period, adjust TV Camera TARGET control clockwise to center position.

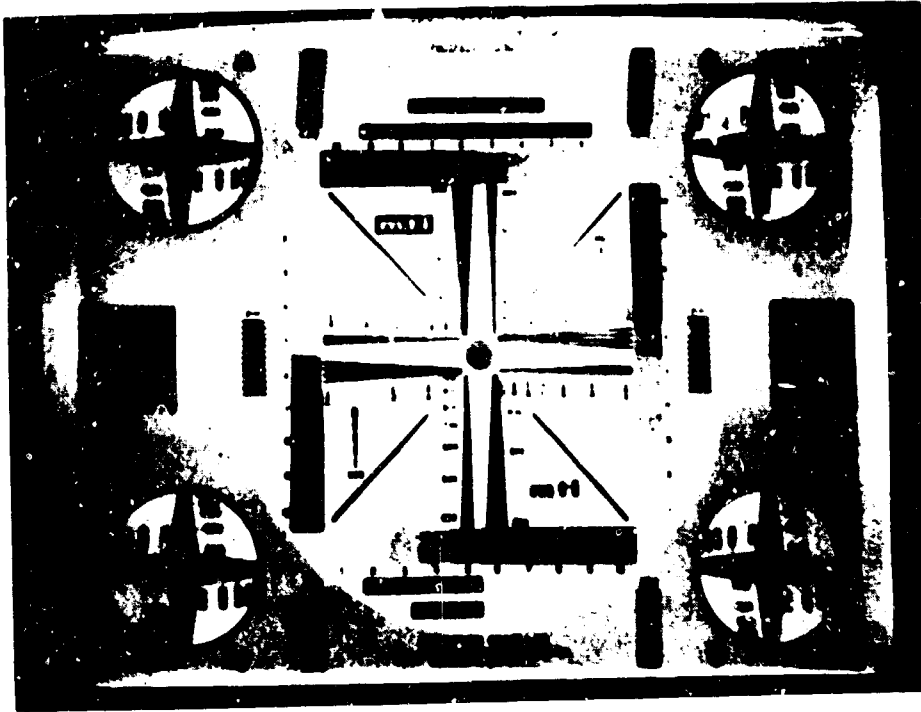
NOTE

Adjust camera lens focus, focal length and aperture controls during next step to acquire proper image on TV Camera vidicon tube.

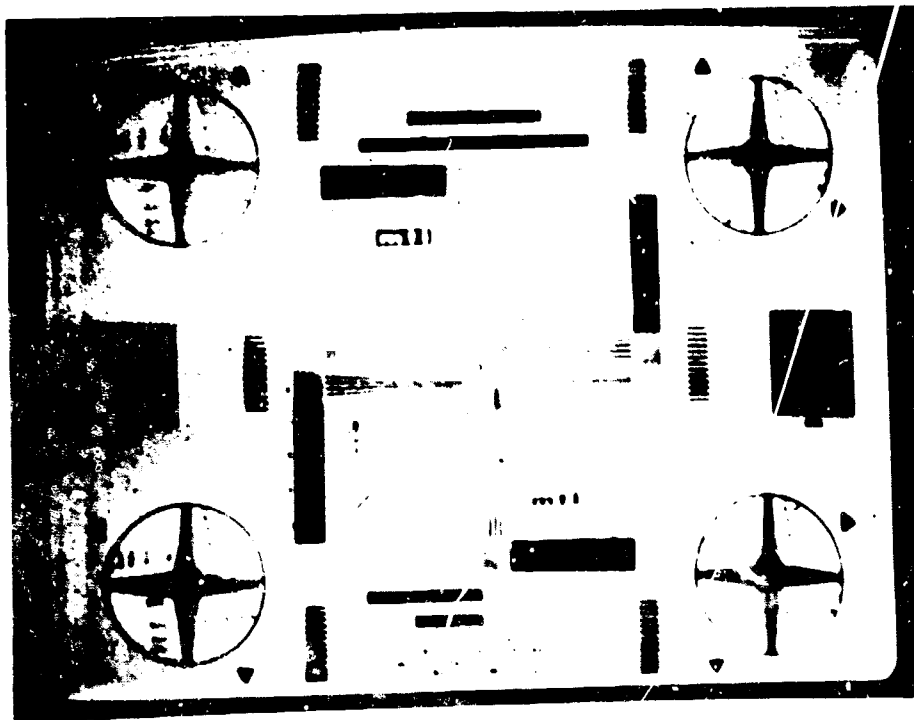
CAUTION

To prevent damage to TV Camera vidicon tube, do not adjust camera BEAM control past point where retrace (black) lines on TV Monitor are visible.

- i. Slowly adjust TV Camera BEAM control clockwise until image appears on TV Monitor.
- j. (See Figure 4-4) Further adjust TV Camera BEAM control until complete image is visible (advancing BEAM control past this point will cause



DETAIL A
NORMAL PICTURE



DETAIL B

FAULT: DISTORTION AND LOSS OF FOCUS (VIDEO LEVEL METER INDICATES OVER 100%)
REMEDY: READJUST TARGET AND BEAM CONTROLS TO LOWER (CCW) POSITION

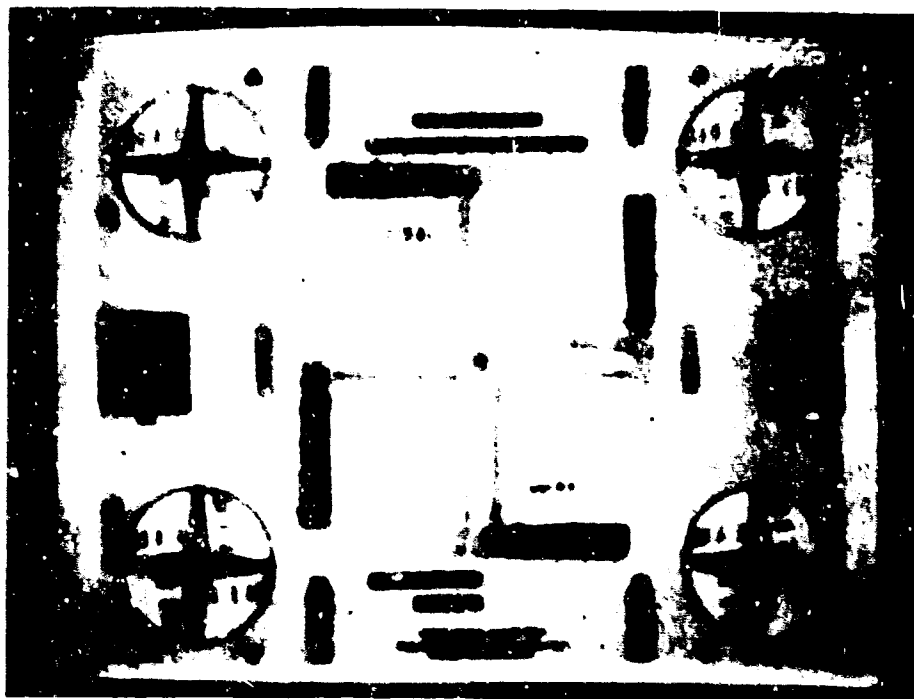
FIGURE 4-4 CAMERA PRESENTATIONS - FAULTS AND REMEDIES



DETAIL C

FAULT: NEGATIVE PICTURE

REMEDY: READJUST TARGET CONTROL TO LOWER (CCW) POSITION



DETAIL D

FAULT: PICTURE OUT OF FOCUS

REMEDY: READJUST FOCUS CONTROL

FIGURE 4-4 TV CAMERA PRESENTATIONS - FAULTS AND REMEDIES

loss of focus and distortion of TV Monitor picture, also probable damage to TV Camera vidicon tube).

RESULT: (Correct) Clear, sharp image appears on TV Monitor.

(Incorrect) Excessive video is present or picture quality is unacceptable, with BEAM control advanced to 90% of full range: adjust TARGET control to a lower position and repeat steps i and j.

- k. Adjust camera lens aperture (f/number), TARGET and BEAM controls until picture highlights are visible on TV Monitor, and TV Camera VIDEO LEVEL meter indicates full scale (100%) deflection.

NOTE

If TARGET control is set to A (auto) position, readjustment of camera lens aperture may be necessary.

- l. Adjust camera lens focus and TV Camera FOCUS control for optimum resolution on TV Monitor.
- m. Adjust TV Monitor CONTRAST and BRIGHT controls to further increase picture quality.

4-12. VIDEO RECORDER TURN-ON AND ADJUSTMENT.

NOTE

Video Recorder heads and guides should be cleaned after every eight hours of use. Refer to Paragraph 7-5, Heads and Guides Cleaning. The Video Recorder heads should be demagnetized after every eight hours of use. Refer to Paragraph 7-4, Heads Demagnetizing.

- a. Set Video Recorder POWER switch to ON.

RESULT: (1) Pilot lamp (to right of S STOP switch) illuminates.

(2) Head drum begins to rotate.

(3) (Correct) Clicking noise (normal) may occur several times, then ceases when head drum reaches synchronous speed.

(Incorrect) Head drum does not appear to reach synchronous speed: set Video Recorder POWER switch

to OFF and manually adjust both reels to allow a small slack in tape. Repeat step a.

- b. Set Video Recorder READY-THREAD switch to READY (switch is normally tight.)

RESULT: Switch clicks into position.

SECTION V

OPERATION

5-1. GENERAL.

5-2. Section V, Operation, provides all procedures required to operate the Video Tape Recording System. The procedures consist of the following paragraphs: Recording Video Only, or Video and Audio (Video Recorder); Playback Only; Simultaneous Recording (Video Recorder and Auxiliary Audio Recorder); and Dubbing Audio on Video Tape.

5-3. The Recording Video Only, or Video and Audio (Video Recorder) procedure provides instructions for accomplishing the primary task of recording a scene on video tape, with or without audio, using the Video Tape Recording System. Playback of the recorded scenes may be accomplished without changing the system configuration. (Refer to Paragraph 5-4 for description of playback with the system in a compact configuration. Refer to Paragraph 5-6 for description of microphone dubbing.)

5-4. The Playback Only procedure details the assembly and operation of the Video Tape Recording System in a compact configuration for playback of recorded video and audio. Generally, playback often occurs in a limited area such as an office or other restricted viewing area, necessitating the compact system configuration.

5-5. The Simultaneous Recording (Video Recorder and Auxiliary Audio Recorder) procedure provides instruction for simultaneously recording on the Video Recorder and the Auxiliary Audio Recorder. The Auxiliary Audio Recorder replaces the microphone during video recording to record audio descriptions of maintenance tasks occurring in areas where a long microphone cable would be cumbersome. When recording ends, the Auxiliary Audio Recorder audio is dubbed onto the Video Recorder tape (refer to the following paragraph).

5-6. The Dubbing Audio on Video Tape procedure provides details on transferring audio onto video tape containing previously recorded video. Either a microphone or the Auxiliary Audio Recorder may be used to provide the audio. The Video Tape Recording System is assembled in a compact configuration to facilitate use in limited areas.

5-7. See Figure 5-1 for a table listing Counter Readings/Total Time. The table uses the Video Recorder counter to derive the operating time of the Video Tape Recording System during recording, playback, fast forward, and rewinding. The counter may also be used to denote certain recorded scenes on the video tape for playback or stillframing at a later time.

COUNTER READINGS			TOTAL TIME (MINUTES)
RECORD/PLAYBACK	FAST FORWARD	REWIND	
23	69	153	1
46	139	364	2
68	208	649	3
89	278	970+	4
110	347		5
131	416		6
151	485		7
171	553		8
191	621		9
210	689		10
229	756		11
249	823		12
266	890		13
285	957		14
303	970		15
320			16
338			17
355			18
372			19
389			20
406			21
422			22
438			23
456			24
470			25
486			26
502			27
517			28
532			29
547			30
562			31
577			32
592			33
606			34
621			35
635			36
649			37
663			38

FIGURE 5-1 TABLE OF COUNTER READINGS AND TOTAL TIME

5-8. RECORDING/PLAYBACK.

5-9. RECORDING VIDEO ONLY, OR VIDEO AND AUDIO (VIDEO RECORDER).

NOTE

Following procedure uses Video Tape Recording System to record scenes, either video or video and audio, on Video Recorder.

- a. Check availability of Video Tape Recording System components. Refer to Paragraph 3-4, Parts Inventory.
- b. Prepare Video Tape Recording System for recording and playback. Refer to Paragraph 3-7, Preparation for Recording and Playback.
- c. Perform preliminary adjustments and apply power to Video Tape Recording System. Refer to Section IV, Turn-on and Adjustment.
- d. Set Video Recorder AUDIO OUTPUT LEVEL control fully ccw.
- e. Set Video/Audio Junction Box VIDEO switch to MON and VTR.
- f. Set Video Recorder VIDEO lever to RECORD (AUDIO lever moves automatically to RECORD).
- g. Adjust Video Recorder RECORD LEVEL VIDEO control until VIDEO meter indicates 100% (peak). Do not allow meter to indicate over 100%.
- h. If audio is to be recorded with video, perform steps i through k. If audio is not to be recorded, proceed to step l.
- i. Set Video Recorder AUDIO INPUT switch to MICROPHONE.
- j. Set Video/Audio Junction Box MIC SELECT switch to one of following positions, depending on choice of audio input: MIC 1; MIC 2; or HFADSET.

NOTE

Headphones (16 ohms or higher impedance) may be used during following step to monitor audio input for presence of acoustic feedback. If headphones are used, set Audio Output Selector switch on Video Recorder rear panel to LINE (disabling speaker) and connect

headphones to front panel HEADPHONES
jacks. Adjust AUDIO OUTPUT LEVEL
control during next step for acceptable
audio level.

- k. Simulate expected distance between microphone or headset and speaking person. Set switch on headset (if used) to on position. Speak in normal manner and adjust Video Recorder RECORD LEVEL Audio control until AUDIO meter peaks at 100%.

- l. To begin recording, press Video Recorder R RECORD switch, or (if connected) Remote Control Unit R switch.

RESULT: (1) Video Recorder RECORD lamp (to right of R RECORD switch) illuminates.

(2) Remote Control Unit (if connected) R lamp illuminates.

(3) Video Recorder counter rotates.

(4) Video Recorder records video or video/audio.

- m. Refer to Figure 5-1, Table of Counter Readings/Time, for listing of counter readings and corresponding recording time of system.

- n. To stop recording, press Video Recorder S STOP switch, or (if connected) Remote Control Unit S switch.

RESULT: (1) Video Recorder RECORD lamp extinguishes.

(2) Remote Control Unit (if connected) R lamp extinguishes.

(3) Video Recorder counter stops rotating.

(4) Video Recorder stops recording.

- o. To rewind, play back, wind forward (fast forward), or stillframe video tape, perform procedures given in Paragraph 5-23, Video Recorder Modes.

- p. Perform one of following steps:

- 1. If Video Tape Recording System is to be moved to a new area for further recording, perform Paragraph 6-3, Short Period Shut-down.
- 2. If Video Tape Recording System is to be used for playback only, perform Paragraph 6-3, Short Period Shut-down, then Paragraph 5-10, Playback Only.

3. If no further use of Video Tape Recording System is required, perform Paragraph 6-4, Shut-down For Storage.
4. If audio dubbing (microphone only) is to be applied to video tape, perform Paragraph 6-3, Short Period Shut-down, then Paragraph 5-19, Dubbing Audio On Video Tape.

5-10. **PLAYBACK ONLY.**

NOTE

Following procedure uses Video Tape Recording System in a playback only configuration. Recording of video or audio is not possible.

- a. Check availability of Video Tape Recording System components. Refer to Paragraph 3-4, Parts Inventory.
- b. Prepare Video Tape Recording System for playback only. Refer to Paragraph 3-15, Preparation For Playback or Audio Dubbing Only.
- c. Perform preliminary adjustments and apply power to Video Tape Recording System. Refer to Section IV, Turn-on and Adjustment (do not perform Paragraph 4-11, Camera Turn-on and Adjustment).
- d. To play back recorded video, or video and audio, perform Paragraph 5-25, Playback.
- e. If no further use of Video Tape Recording System is required, perform Paragraph 6-4, Shut-down For Storage.

5-11. **SIMULTANEOUS RECORDING (VIDEO RECORDER AND AUXILIARY AUDIO RECORDER).**

NOTE

The following procedures are to be used for simultaneously recording video on the Video Recorder and audio on the Auxiliary Audio Recorder. The procedures consist of preparing the Auxiliary Audio Recorder and performing simultaneous recording using both recorders. Also included are procedures covering depleted tape, stopping recording, and rewinding tape on the Auxiliary Audio Recorder.

5-12. **Preparation.**

- a. Check availability of Video Tape Recording System components. Refer to Paragraph 3-4, Parts Inventory.

- b. Prepare Video Tape Recording System for recording. Refer to Paragraph 3-7, Preparation for Recording and Playback.
- c. Perform preliminary adjustments and apply power to Video Tape Recording System. Refer to Section IV, Turn-on and Adjustment.
- d. (See Figure 5-2.) Momentarily press Forward switch (13) on Auxiliary Audio Recorder and observe REC. BATT. indicator (23). If indicator is in red region, battery must be immediately recharged. Refer to Paragraph 5-18, Recharging Battery.
- e. Press Stop switch (14) on Auxiliary Audio Recorder.
- f. Press CASSETTE UP lever (22) on Auxiliary Audio Recorder (1), opening compartment lid (8).
- g. Place tape cassette (2) into compartment (10) and press cassette until cassette snaps into place. Carefully close lid (8).

NOTE

AUX jack (18) is not used with Video
Tape Recording System.

- h. (See Detail A, Figure 5-2) Grasp microphone (4) and insert microphone plug (7) into MIC (16) and REMOTE (17) jacks on recorder (1).
 - i. Set microphone ON-OFF switch (5) to OFF
 - j. Simultaneously press Auxiliary Audio Recorder REC (11) and Forward (13) switches, locking switches into place. Auxiliary Audio Recorder is now ready for recording.
 - k. Before simultaneous recording begins enter a few minutes of normal audio on Auxiliary Audio Recorder tape to provide for later audio level adjustment, as follows: set microphone ON-OFF switch (5) to ON; hold microphone seven inches from mouth and say "testing, testing, one, two, three," several times into microphone grill (6); set microphone ON-OFF switch to OFF; Press Stop switch (14).
- 5-13. Recording. See Figure 5-2.
- a. Ensure Auxiliary Audio Recorder microphone ON-OFF switch (5) is set to OFF.
 - b. Initiate normal video and audio recording using Video Recorder. Refer to steps d through m, Paragraph 5-9, Recording Video Only, or Video and Audio. Video Recorder should now be recording video and audio.

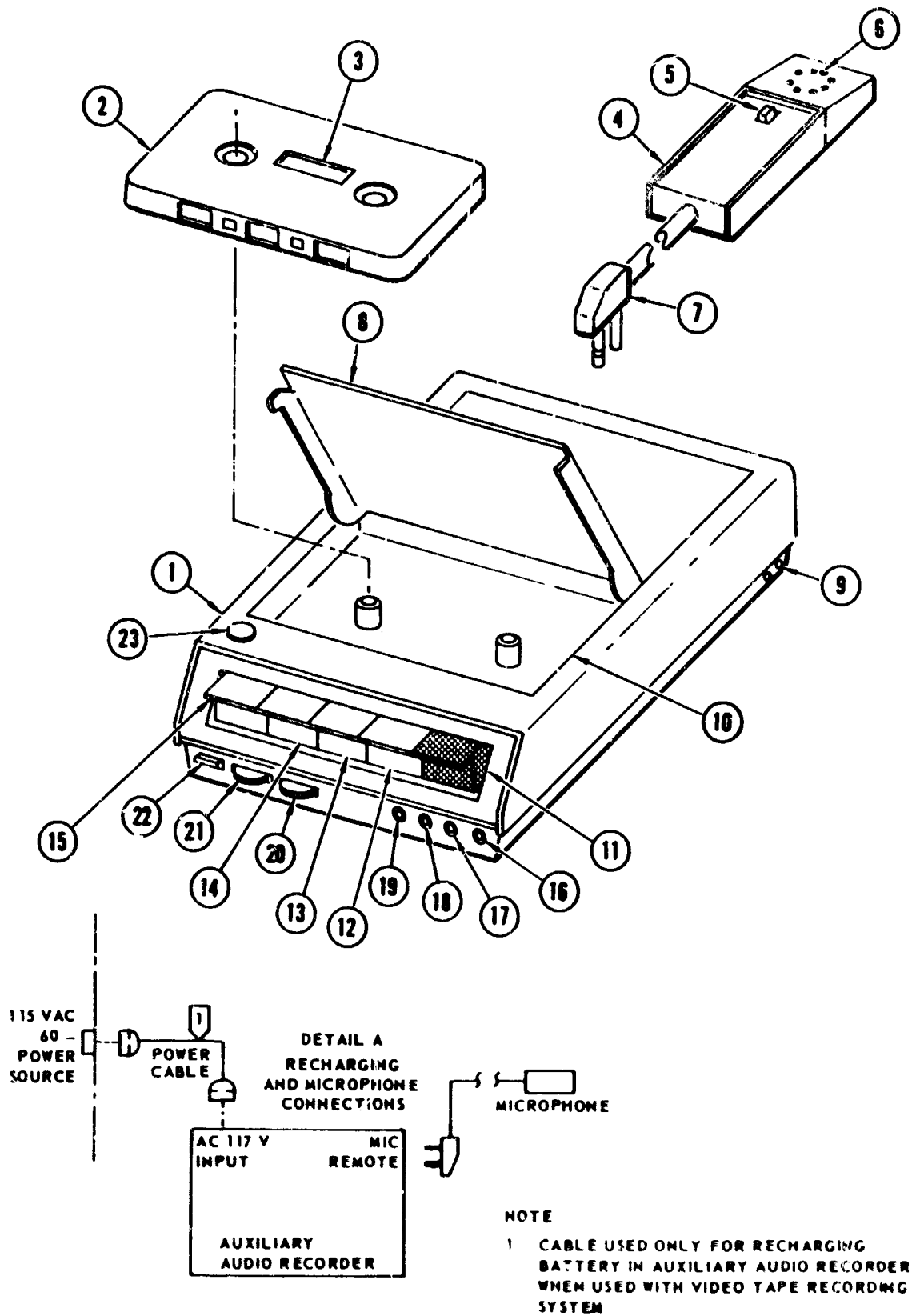


FIGURE 5-2 AUXILIARY AUDIO RECORDER

INDEX

1. AUXILIARY AUDIO RECORDER (SONY-MATIC TC-100)
2. TAPE CASSETTE
3. TAPE REMAINING WINDOW
4. MICROPHONE, AUXILIARY AUDIO RECORDER
5. (ON-OFF) REMOTE CONTROL SWITCH
6. MICROPHONE GRILL
7. MICROPHONE PLUG
8. COMPARTMENT LID
9. AC 117 V INPUT
10. COMPARTMENT
11. (REC) RECORD SWITCH
12. (FF) FAST FORWARD SWITCH
13. (F) FORWARD SWITCH
14. (S) STOP SWITCH
15. (R) REWIND SWITCH
16. (MIC) MICROPHONE INPUT JACK
17. (REMOTE) REMOTE CONTROL JACK
18. (AUX) AUXILIARY INPUT JACK
19. (MONITOR) MONITOR JACK
20. (VOL) VOLUME CONTROL
21. (TONE) TONE CONTROL
22. (CASSETTE UP) CASSETTE EJECTOR LEVER
23. (REC BATT) RECORD/BATTERY INDICATOR

FIGURE 5-2 AUXILIARY AUDIO RECORDER

- c. Simultaneously press Auxiliary Audio Recorder REC (11), and Forward (13) switches, locking switches into place. Auxiliary Audio Recorder is now ready for recording.

NOTE

To conserve tape on Auxiliary Audio Recorder, do not initiate recording until specific maintenance task to be recorded is about to take place. Previous recordings on tape will be automatically erased during subsequent recording. Observe tape remaining window (3) on tape cassette (2) during recording to prevent sudden interruptions due to tape depletion.

- d. Set Auxiliary Audio Recorder microphone ON-OFF switch (5) to ON.

RESULT: Auxiliary Audio Recorder begins to operate.

NOTE

Use progressive cueing ("mark 1 - mark 2 - mark 3 - etc.") at each start of Auxiliary Audio Recorder. Say "termination 1 - termination 2 - termination 3 - etc.," at each turn-off of Auxiliary Audio Recorder.

- e. Before applying audio to Auxiliary Audio Recorder, provide audio cueing to both recorders by saying "mark (number)" into microphones of both recorders (hold Auxiliary Audio Recorder microphone seven inches from mouth, leaving small square in back of microphone uncovered). Recording of normal audio may now begin.
- f. If tape on Auxiliary Audio Recorder becomes depleted, proceed to Paragraph 5-16, Depleted Tape Replacement.

NOTE

During simultaneous recording, it may be necessary to turn off Auxiliary Audio Recorder to conserve tape. However, Video Recorder may be allowed to continue recording video. If both recorders are to be turned off, do so simultaneously. (Do not turn off Video Recorder, leaving Auxiliary Audio Recorder operating, or cueing procedure will be disrupted.) Refer to following step:

- g. To stop recording with Auxiliary Audio Recorder, or with both recorders, proceed to Paragraph 5-14, Stop Recording.

5-14. Stop Recording. See Figure 5-2.

NOTE

To stop Auxiliary Audio Recorder, perform step a. To stop Auxiliary Audio Recorder and Video Recorder simultaneously, perform steps a and b simultaneously.

- a. To stop Auxiliary Audio Recorder, say "termination (number)" into both microphones and set Auxiliary Audio Recorder microphone ON-OFF switch (5) to OFF. Proceed to step c.
- b. To stop Video Recorder, press S STOP switch, or (if connected) Remote Control Unit S switch. Proceed to step c.
- c. Perform one of following steps if recording is to be resumed (if not, proceed to step d):
 1. If only Auxiliary Audio Recorder was stopped, resume recording by repeating steps d through g, Paragraph 5-13, Recording.
 2. If both recorders were stopped, resume recording by repeating Paragraph 5-13, Recording.
- d. If all recording is ended, perform Paragraph 5-17, Rewinding Tape, then transfer Auxiliary Audio Recorder audio onto Video Recorder tape (may be done at later time) per Paragraph 5-19, Dubbing Audio on Video Tape.

5-15. Auxiliary Audio Recorder Modes.

5-16. Depleted Tape Replacement. (See Figure 5-2)

- a. If tape becomes depleted during recording, say "termination (number)" into both microphones. Set Auxiliary Audio Recorder microphone ON-OFF switch (5) to OFF (allow Video Recorder to continue recording).
- b. Press Stop switch (14) on Auxiliary Audio Recorder.
- c. Press Cassette Up switch (22), sliding switch to left of arrow points until compartment lid (8) opens.
- d. If only one side of tape is depleted, flip tape cassette (2) over and resume recording. Refer to steps c through g, Paragraph 5-13, Recording.
- e. If both sides of tape are depleted, rewinding is not necessary. Replace depleted cassette (2) with unused cassette and resume recording. Refer to steps c through g, Paragraph 5-13, Recording.

5-17. Rewinding Tape. (See Figure 5-2)

- a. Set microphone ON-OFF switch (5) to OFF.
- b. Press Auxiliary Audio Recorder Stop switch (14) and perform one of following steps:
 1. If both sides of tape are depleted, rewinding is not necessary. Press CASSETTE UP switch (22), sliding switch to left of arrow points until compartment lid (10) opens. Flip tape cassette (2) over and carefully close lid. Tape is now ready for playback or audio dubbing.
 2. If one side of tape is partially depleted and other side is unused, rewind tape by pressing Rewind switch (15). When tape is rewound, press Stop switch (14). Tape is now ready for playback or audio dubbing.
 3. If one side of tape is depleted, but other side (side in use) is only partially depleted, press Fast Forward switch (12). When tape runs out, press Stop switch (14). Press CASSETTE UP switch (22), sliding switch to left of arrow points until compartment lid (10) opens. Flip tape cassette (2) over and carefully close lid. Tape is now ready for playback or audio dubbing.

5-18. Recharging Battery. See Figure 5-2.

NOTE

If Auxiliary Audio Recorder REC. BATT. indicator (23) is in red region during playback, battery must be recharged per following procedure.

- a. See Figure 5-2, Detail A. Connect power cable to AC 117V INPUT jack on Auxiliary Audio Recorder and to 115 vac 60 cycle power source (charging begins when cable is connected).
- b. Recharge battery for 21 hours. Do not overcharge. When recharged, battery will operate recorder for 10 hours of continuous operation.
- c. When battery is recharged, disconnect power cable. Press Forward switch (13) and observe REC. BATT. indicator (23). If indicator still indicates in red region, replace (BF-9) battery.

5-19. DUBBING AUDIO ON VIDEO TAPE.

5-20. Preparation.

NOTE

Following procedure prepares Video Tape Recording System for dubbing audio on video tape containing previously recorded video (any audio that exists on the video tape will be automatically erased during dubbing). Either a microphone or the Auxiliary Audio Recorder may be used for dubbing. If Auxiliary Audio Recorder is used, Paragraph 5-11, Simultaneous Recording (Video Recorder and Auxiliary Audio Recorder), must be performed first.

- a. Check availability of Video Tape Recording System components. Refer to Paragraph 4-3, Parts Inventory.
- b. Prepare Video Tape Recording System for audio dubbing. Refer to Paragraph 3-15, Preparation For Playback or Audio Dubbing Only.
- c. Perform preliminary adjustments and apply power to Video Tape Recording System. Refer to Section IV, Turn-on and Adjustment (do not perform Paragraph 4-11, Camera Turn-on and Adjustment).
- d. Set Video Recorder RECORD LEVEL AUDIO and VIDEO controls fully ccw.

CAUTION

To avoid erasing existing video on tape, Video Recorder VIDEO lever must be set to PLAY.

- e. Apply power to TV monitor.
- f. If microphone is to be used for dubbing, proceed to Paragraph 5-21, Microphone Dubbing.
- g. If Auxiliary Audio Recorder is to be used for dubbing, proceed to Paragraph 5-22, Auxiliary Audio Recorder Dubbing.

5-21. Microphone Dubbing.

- a. Perform Paragraph 5-20, Preparation.
- b. Set Video Recorder AUDIO INPUT switch to MICROPHONE.

- c. Simulate expected distance between microphone and speaking person. Speak in normal manner and adjust Video Recorder RECORD LEVEL AUDIO control until AUDIO LEVEL meter peaks at 100%.

NOTE

To avoid erasing existing video on video tape, Video Recorder VIDEO lever must be set to PLAY.

- d. Set Video Recorder VIDEO lever to PLAY.
- e. Set Video Recorder AUDIO lever to RECORD.
- f. Initiate playback by pressing Video Recorder P Play switch.

RESULT: Video Recorder plays back video on TV monitor
(adjust controls on monitor for acceptable picture).

- g. (See Figure 5-3) Slowly adjust Video Recorder TRACKING control from fully ccw position until VIDEO meter indication is maximum and TV raster is unbroken and free from streaking.
- h. (See Figure 5-3) Adjust Video Recorder TENSION control until top of picture, viewed on TV monitor, is straight (not bent left nor right).
- i. Begin audio dubbing, when desired, by speaking into microphone.
- j. Perform one of following steps:
 - 1. To skip areas of video tape during audio dubbing, perform Paragraph 5-26, Fast Forward.
 - 2. To stop audio dubbing, press Video Recorder S STOP switch.
RESULT: Video Recorder stops playback.
 - 3. To rewind video tape, perform Paragraph 5-24, Rewinding Tape.
 - 4. To play back video tape, perform Paragraph 5-25, Playback.
- k. If no further use of the Video Tape Recording System is required, perform Paragraph 6-4, Shut-down For Storage.

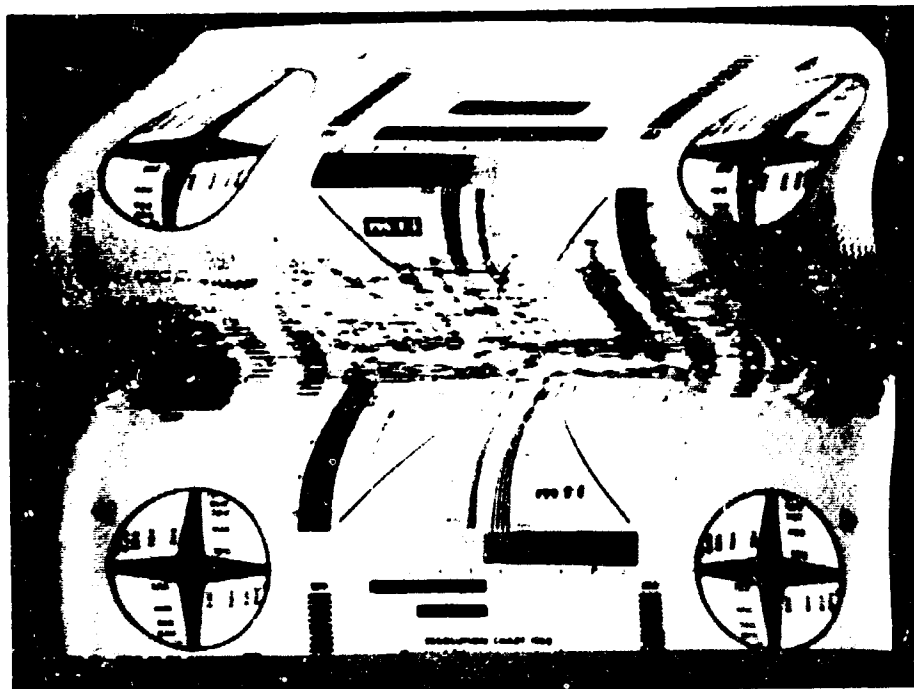
5-22. Auxiliary Audio Recorder Dubbing.

- a. Perform Paragraph 5-20, Preparation.

NOTE

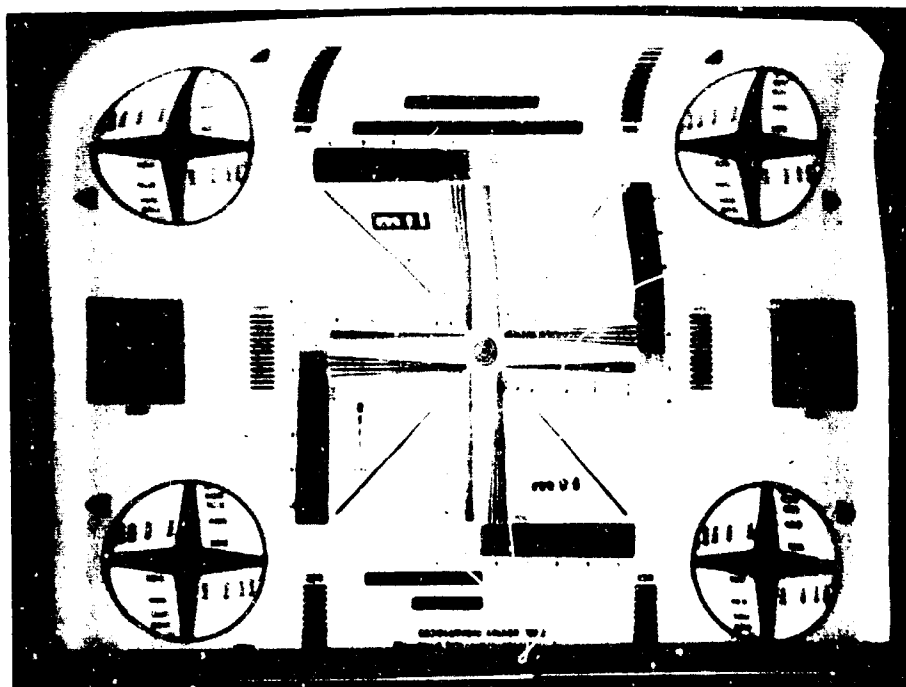
Do not actuate Video Recorder until instructions specify actuation. Do not overrun first audio cue - "mark 1" - on Auxiliary Audio Recorder.

- b. Set Video Recorder AUDIO INPUT switch to BALANCED OR UNBALANCED.



DETAIL A

FAULT: PICTURE BROKEN AND MARRED BY STREAKING
REMEDY: READJUST VIDEO RECORDER TRACKING CONTROL



DETAIL B

FAULT: PICTURE BENT LEFT OR RIGHT
REMEDY: READJUST VIDEO RECORDER TENSION CONTROL

FIGURE 5-3 – VIDEO RECORDER PRESENTATIONS -- FAULTS AND REMEDIES

- c. Press Auxiliary Audio Recorder CASSETTE UP lever, opening compartment lid. Place tape cassette containing previously recorded audio into compartment and press cassette until cassette snaps into place. Carefully close lid.
- d. Press Forward switch on Auxiliary Audio Recorder and adjust VOL and TONE controls for normal listening level.
- e. Adjust Video Recorder RECORD LEVEL AUDIO control to obtain 100% peak indication on AUDIO meter.
- f. Press Stop switch on Auxiliary Audio Recorder a considerable time before first audio cue - "mark 1" - is heard.

NOTE

To avoid erasing existing video and audio on video tape, Video Recorder VIDEO and AUDIO levers must be set to PLAY

- g. Set Video Recorder VIDEO and AUDIO levers to PLAY.

NOTE

Do not overrun first audio cue - "mark 1" - on Video Recorder during following steps.

- h. To begin setup of Video Recorder, press P PLAY switch.

RESULT: Video Recorder plays back video on TV monitor (adjust controls on monitor for acceptable picture).

- i. (See Figure 5-3) Slowly adjust Video Recorder TRACKING control from fully ccw position until VIDEO meter indication is maximum and TV raster is unbroken and free from streaking.
- j. (See Figure 5-3) Adjust Video Recorder TENSION control until top of picture, viewed on TV monitor, is straight (not bent left or right).
- k. Stop Video Recorder playback when first audio cue - "mark 1" - is heard on Video Recorder, by quickly pressing S STOP switch.

RESULT: Video Recorder stops playback.

- l. Set Video Recorder AUDIO lever to RECORD.

- m. Press Forward switch on Auxiliary Audio Recorder. When first audio cue - "mark 1" - is heard initiate dubbing by quickly pressing Video Recorder R RECORD Switch.

RESULT: Auxiliary Audio Recorder dubs audio onto Video Recorder tape.

- n. When audio cue "termination 1" is heard, simultaneously press Stop switch on Auxiliary Audio Recorder and Video Recorder S STOP switch. Set Video Recorder AUDIO lever to PLAY. Press Video Recorder P PLAY switch and repeat steps k thru n (for "mark 2", then "termination 2"). Repeat for all "marks" and "terminations."

- o. Perform one of following steps:

1. To skip areas of video tape during audio dubbing, perform Paragraph 5-26, Fast Forward.
2. To rewind video tape, perform Paragraph 5-24, Rewinding Tape.
3. To rewind Auxiliary Audio Recorder tape, perform Paragraph 5-17, Rewind Tape.
4. To play back video tape, perform Paragraph 5-25, Playback.

- p. If no further use of the Video Tape Recording System is required, perform Paragraph 6-4, Shutdown For Storage.

5-23. VIDEO RECORDER MODES.

5-24. REWINDING TAPE.

NOTE

Following procedure is used to rewind video tape, even if tape is in recording mode or playback mode. (It is not necessary to press Video Recorder S STOP switch in following steps.)

- a. Refer to Figure 5-1, Table of Counter Readings/Time, for time necessary to rewind tape.
- b. Set Video Recorder REWIND-STOP-FORWARD switch to REWIND.

RESULT: Video Recorder begins to rewind.

- c. To stop rewind, set REWIND-STOP-FORWARD switch to STOP.

RESULT: Video Recorder stops rewind.

5-25. **PLAYBACK.**

- a. Refer to Figure 5-1, Counter Readings/Time, for time necessary to play back tape. Ensure tape is rewound. Refer to paragraph 5-24, Rewinding Tape.
- b. Set Video Recorder AUDIO and VIDEO levers to PLAY.
- c. Press Video Recorder P PLAY switch, or (if connected), Remote Control Unit P switch.

RESULT: (1) Video Recorder plays back video on TV Monitor and audio on recorder speaker.
(2) If Remote Control Unit is connected, white lamp on unit illuminates.

- d. If video tape contains audio, adjust Video Recorder AUDIO OUTPUT LEVEL control until recorder speaker volume is acceptable.

NOTE

During playback, occasionally readjust TRACKING control to maintain maximum indication on VIDEO meter.

- e. (See Figure 5-3) Slowly adjust Video Recorder TRACKING control from fully ccw position until VIDEO meter indication is maximum and TV raster is unbroken and free from streaking.
- f. (See Figure 5-3) Adjust Video Recorder TENSION control until top of picture, viewed on TV Monitor, is straight (not bent left nor right).
- g. To skip areas of tape during playback, refer to Paragraph 5-26, Fast Forward.
- h. If a stillframe (stopping recorder to view a single field) is desired, refer to Paragraph 5-27, Stillframe.
- i. To stop playback, press Video Recorder S STOP switch, or (if connected), Remote Control Unit S switch.

RESULT: (1) Video Recorder stops playback.
(2) If Remote Control Unit is connected, white lamp on unit extinguishes.

5-26. FAST FORWARD.

NOTE

Following procedure allows skipping of sections of video tape during playback or record modes (it is not necessary to press Video Recorder S STOP switch in following steps).

- a. Ensure that area of tape desired for playback or recording has been identified by noting Video Recorder counter reading. Refer to Figure 5-1, Table of Counter Readings/Time, for time necessary to reach desired tape area.

- b. Set Video Recorder REWIND-STOP-FORWARD switch to FORWARD.

RESULT: Tape reels accelerate in speed (recording or playback is interrupted).

- c. When counter reading indicates that desired tape area has been reached, stop fast forward by setting REWIND-STOP-FORWARD switch to STOP.

RESULT: Video Recorder stops fast forward.

- d. Press P PLAY switch to continue playback, or R RECORD switch to continue recording.

5-27. STILLFRAME.

NOTE

Following procedure is used to stop Video Recorder during playback, allowing a single field to be viewed on TV Monitor.

- a. Ensure Video Recorder is in playback mode. Refer to Paragraph 5-25, Playback.
- b. Use counter on Video Recorder to denote area of tape to be stillframed.
- c. Continue to operate Video Recorder in playback mode; if desired, place recorder into fast forward mode (refer to Paragraph 5-26, Fast Forward) until counter indicates that desired tape area is approaching, then place recorder back to playback mode.

- d. When desired field appears on TV Monitor, press Video Recorder S STOP switch, or (if connected) Remote Control Unit S switch.

RESULT: Video Recorder stops playback and automatically stillframes desired scene (if picture has diagonal lines, or is torn, manually rotate reels until picture shows a stillframe).

SECTION VI

SHUT-DOWN

6-1. GENERAL.

6-2. Section VI, Shut-down, details the partial disassembly of the Video Tape Recording System for short period shut-down, or complete disassembly for storage or shipping.

6-3. SHORT PERIOD SHUT-DOWN. See Figure 3-2.

NOTE

Following procedure partially disassembles Video Tape Recording System to allow rapid transport of system to another maintenance task area if playback is to be performed, or to await further use.

- a. If Video Recorder is in process of recording or playback, rewind tape and remove from Video Recorder. Refer to Paragraph 5-24, Rewinding Tape.
- b. If illumination was used, turn off lights and disconnect electrical cable W9 from lights and power source. Place cable W9 on reel No. 4 on Television Cart and install retainer over reel.
- c. Ensure all switches and controls are positioned as given in Paragraph 4-5, Controls Preliminary Settings.
- d. Disconnect electrical cable W5 or W6 from power source and Television Cart. If electrical cable W5 was used, store cable on reel No. 1 and install retainer ring. If electrical cable W6 was used, place cable in storage provision in Television Cart.
- e. If microphone(s) or headset was used, remove from MIC and HEADSET jacks on Video/Audio Junction Box and place in storage provision in Television Cart.
- f. If extra TV monitor was used, disconnect electrical cable W10 from extra TV monitor and Camera Station TV Monitor. Disconnect power cable from Television Cart power input receptacle.
- g. Disconnect electrical cable W11 from Television Cart and Video Recorder.

- h. Disconnect electrical cable bundle W8 from Video Recorder and Video/Audio Junction Box. Store cable bundle W8 on reel No. 2 and replace retainer ring.
 - i. Disconnect electrical cable W7 from Television Cart ac power receptacle and from plug on System Power Distribution Box. Store cable W7 on reel No. 3 and replace retainer ring.
 - j. Clean Video Recorder heads and guides. Refer to Paragraph 7-5, Heads and Guides Cleaning. Demagnetize heads. Refer to Paragraph 7-4, Heads Demagnetizing.
- 6-4. SHUT-DOWN FOR STORAGE. See Figure 3-2.

NOTE

Following procedure completely disassembles
Video Tape Recording System for storage or
shipping.

- a. Perform Paragraph 6-3, Short Period Shut-down.
- b. Disconnect TV Camera power cable and TV Monitor power cable from System Power Distribution Box.
- c. Disconnect electrical cable W4 from Remote Control Unit and Video/Audio Junction Box. Disconnect electrical cable W3 from Video/Audio Junction Box and TV Camera rear panel Video Level meter box.
- d. Disconnect electrical cable W2 from Video Level meter Box and TV Camera rear panel.
- e. Place cables W2, W3 and W4 in storage provision in Television Cart.
- f. Unscrew tee screws on Remote Control Unit; remove unit from camera tripod and place in storage provision in Television Cart.
- g. Unlock locking lever and remove TV Camera from mount on tripod. Slide camera onto holding lunge in Television Cart and secure by rotating jam nut ccw until tight.
- h. Loosen two philips-head screws and remove camera mount from engaging pins on tripod. Place mount in storage provision in Television Cart.
- i. Disconnect electrical cable W1 from Video/Audio Junction Box.
- j. Remove System Power Distribution Box and Video/Audio Junction Box from camera tripod, and place in storage provisions in Television Cart.

- k. Use allen wrench to loosen bolts on mounting blocks and remove from camera tripod. Place mounting blocks in storage provision in Television Cart.
- l. Lower TV Monitor mounting bracket to horizontal position. Remove bungee straps from over TV Monitor and from mounting bracket. Remove TV Monitor from bracket (slide power cable and electrical cable V1 through opening in back of bracket).
- m. Disconnect electrical cable W1 from TV Monitor and place cable and TV Monitor in storage provisions in Television Cart.
- n. Remove pins and lift camera tripod off tripod dolly. Close tripod legs and secure legs together by tightening knurled knob that attaches supports to center column.
- o. Remove wing-nuts and U-bolts, and remove TV Monitor mounting bracket from spreader arms on dolly. Screw wing-nuts on U-bolts. Place U-bolts and bracket in storage provisions in Television Cart.
- p. Fold spreaders on tripod dolly (do not pinch hands) and fold dolly.

SECTION VII
PREVENTIVE MAINTENANCE

7-1. GENERAL.

7-2. Section VII, Preventive Maintenance, provides instructions on periodic maintenance to be performed on certain units of the Video Tape Recording System.

7-3. VIDEO RECORDER.

7-4. HEADS DEMAGNETIZING.

See Figure 7-1.

NOTE

Video recorder heads should be demagnetized after every eight hours of use. Only three of five heads need to be demagnetized: video head (3) in head drum (2); audio record/playback head (11); and control track head (13). Do not touch heads with demagnetizer at any time.

- a. Ensure tape is not threaded on Video Recorder.
 - b. Connect Robins demagnetizer, Model HD-6, to 115 vac 60 cycle power.
 - c. Hold demagnetizer close to, but not touching, the head to be demagnetized. Slowly move demagnetizer up and down head face, then slowly withdraw demagnetizer to three feet away from head.
 - d. Demagnetize other heads in same manner.
 - e. Remove demagnetizer and disconnect from 115 vac 60 cycle power.
- 7-5. HEADS AND GUIDES CLEANING.

See Figure 7-1.

NOTE

Video Recorder heads and guides should be cleaned after every eight hours of use.

- a. Remove supply and take-up reels from Video Recorder.
- b. Set controls and switches on Video Recorder as Given in Paragraph 4-5, Controls Preliminary Settings.

- c. Disconnect Video Recorder power cable from Television Cart ac power receptacle.

CAUTION

To prevent damage to Video Recorder, do not spill cleaning fluid on painted or plastic surfaces. Do not use cleaning fluid or rubber capstan (7), otherwise rubber will harden and deform

- d. Apply Magnetic Tape Head Cleaner (spray) (11, Figure 3-2) to video head (3, Figure 7-1) to finish out oxide particles.
- e. Use cotton swabs to apply Ampex Head Cleaner (13, Figure 3-2) to rollers (1, Figure 7-1) and (8), video head (3), guide arms (4), tape guides (5), (6) and (9), and heads (10), (11), (12), and (13).
- f. Apply Isopropyl alcohol to rubber capstan (7) using cotton swab (do not apply any other cleaning fluid).
- g. Connect Video Recorder power cable to ac power receptacle on Television Cart.

7-6. CAMERA.

7-7. LENS AND FACEPLATE CLEANING.

CAUTION

To prevent damage to vidicon tube, do not allow sunlight to strike vidicon faceplate. To prevent damage to vidicon tube caused by residue in tube, do not tilt camera, lens down, at an angle exceeding 45 degrees.

- a. Remove three screws and remove lens mount from TV camera.
- b. Use cotton swabs and high purity ethyl alcohol to clean accumulated dust from faceplate of vidicon tube and from lens. Use spiral motion from middle of faceplate or lens, outward.
- c. Clean smudges or fingerprints from lens.
- d. Replace lens holder and install lens using three screws.

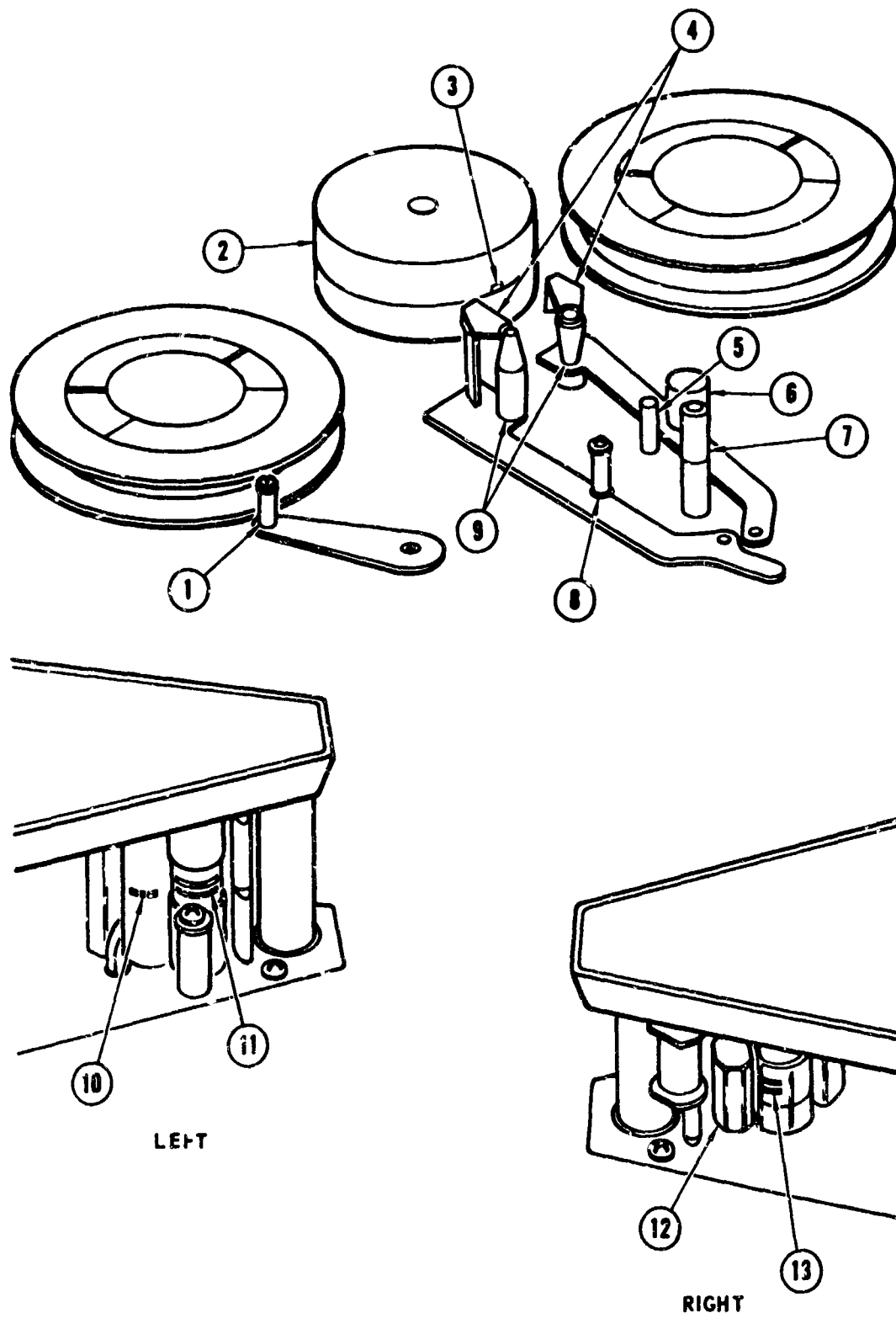
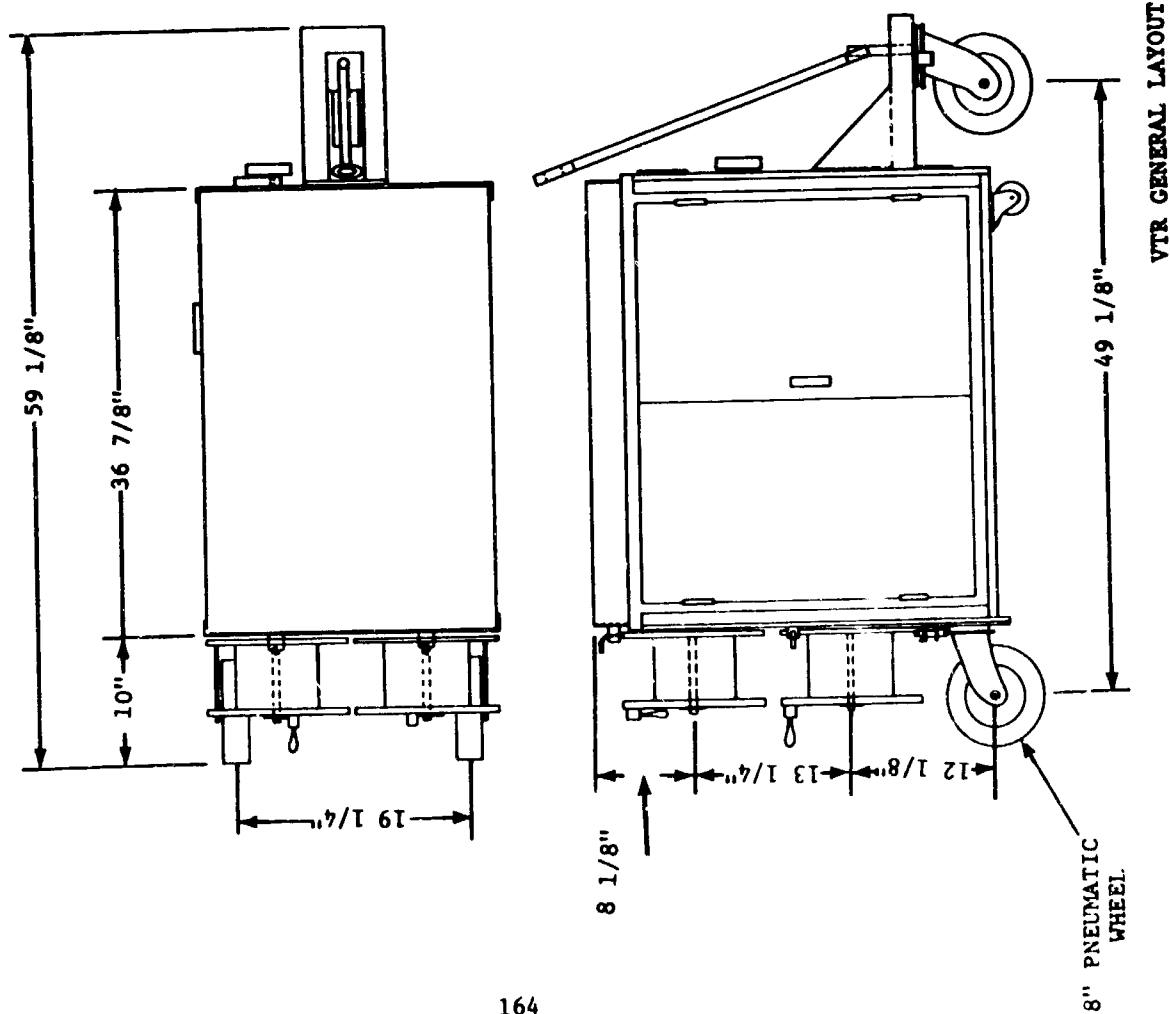
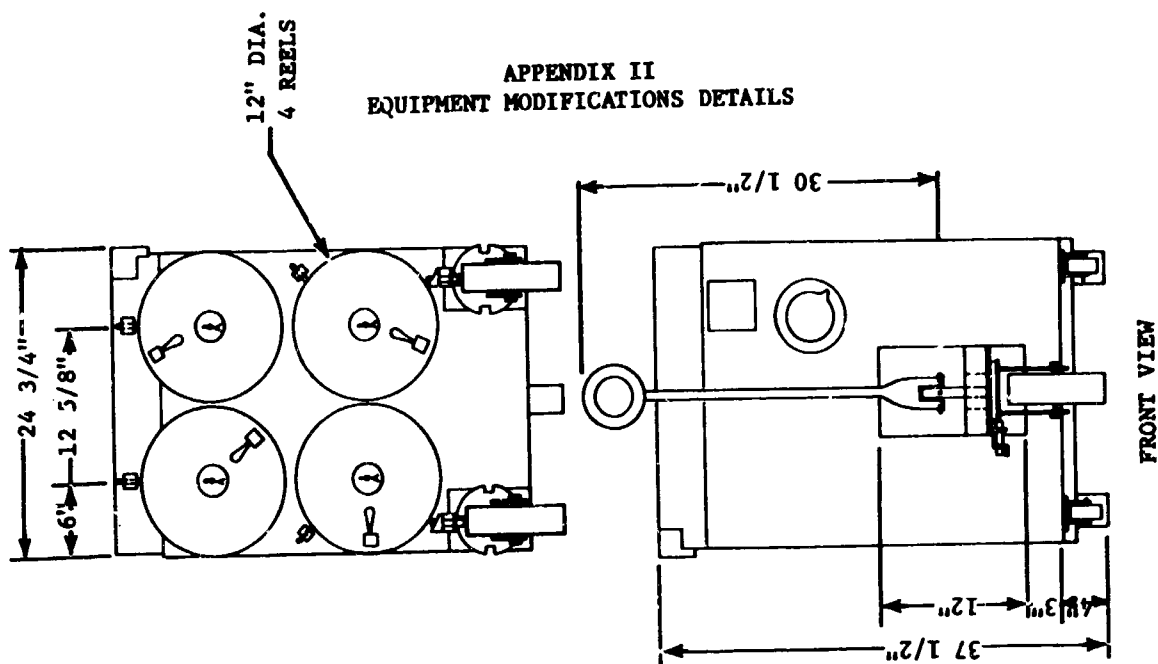


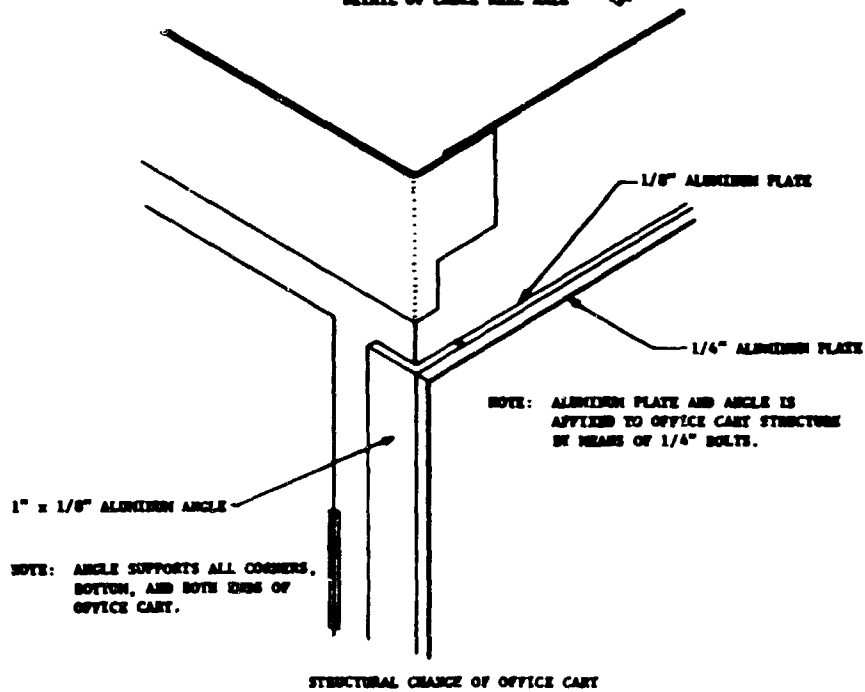
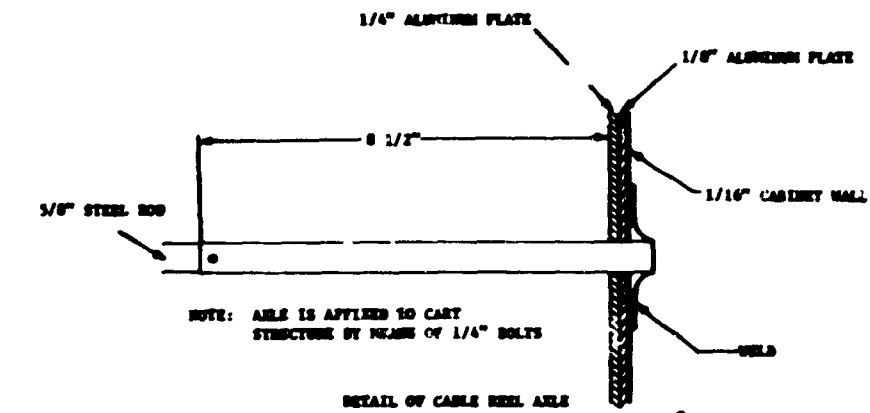
FIGURE 7-1 VIDEO RECORDER HEADS AND GUIDES

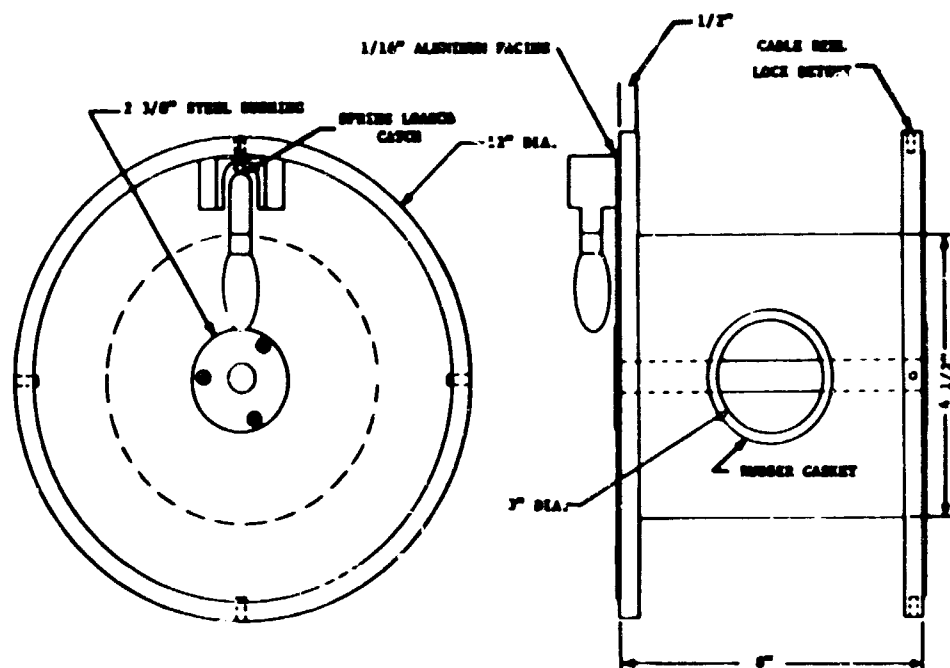
1. ROLLER
2. HEAD DRUM
3. VIDEO HEAD
4. GUIDE ARMS (2)
5. TAPE GUIDE
6. TAPE GUIDE
7. CAPSTAN
8. ROLLER
9. TAPE GUIDES (2)
10. AUDIO ERASE HEAD
11. AUDIO RECORD /PLAYBACK HEAD
12. VIDEO/AUDIO/CONTROL TRACK ERASE HEAD
13. CONTROL TRACK HEAD

FIGURE 7-1 VIDEO RECORDER HEADS AND GUIDES

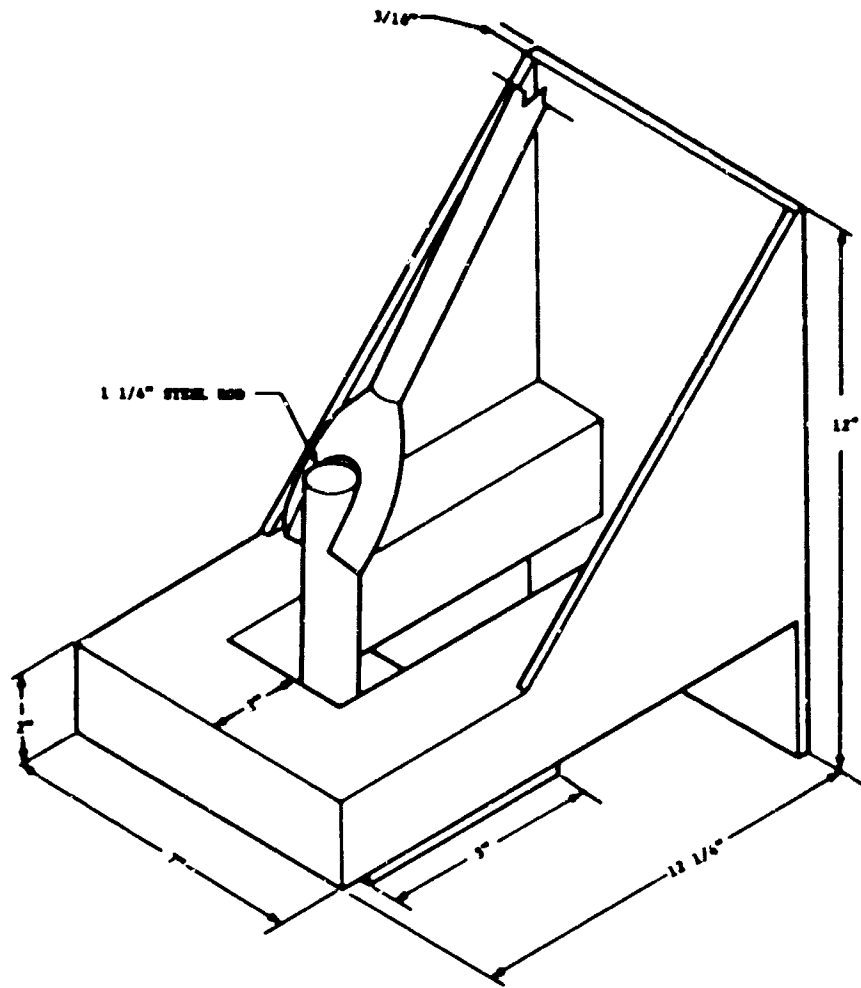
APPENDIX II EQUIPMENT MODIFICATIONS DETAILS







CABLE REEL DETAIL



FRONT WHEEL BOLSTER AND TORQUE ATTACHMENT

APPENDIX III

TECHNICAL SPECIFICATIONS

GPL 700 CAMERA SPECIFICATIONS

ELECTRICAL

POWER REQUIREMENTS

100-130 volts ac, 50 or 60 cps, single phase, 40 watts (max.).

SCANNING STANDARDS

525 lines/frame, random interlace, 30 frames/second, 60 fields/second.
675 lines/frame, 2:1 interlace, 30 frames/second, 60 fields/second.
525 lines/frame, EIA interlace, 30 frames/second, 60 fields/second.

HORIZONTAL RESOLUTION

700 lines in center, 500 lines at corners (with 525 line operation)

BANDWIDTH

10 mc (within 3 db)
88 mc (within 1 db)

AUTO-TARGET CONTROL

Compensates for scene brightness variations up to 4000 to 1.

APERTURE CORRECTION

0 to +10 db

SIGNAL-TO-NOISE RATIO

40 db

SWEEP LINEARITY

Within 1%

SWEEP GEOMETRY

Within 2%

GPL 700 CAMERA SPECIFICATIONS (CONT'D)

MECHANICAL

MOUNTING

Base of camera tapped for standard 1/4 x 20 tripod screws.

LENS MOUNT

Standard 16mm "C" mount.

DIMENSIONS

6.56" high, 4.5" wide, 13.5" long.

WEIGHT

12 pounds.

ENVIRONMENTAL

TEMPERATURE

Continuous operation over an ambient air temperature range of +50°C to -10°C (+122°F to +14°F). (At elevated temperatures a heat dissipating base should be used.)

MODEL 7000, VIDEO TAPE RECORDER SPECIFICATIONS

POWER REQUIREMENTS

105 to 125 volts, 60 cycle at 2-1/2 amperes
Detachable 3 wire power cable and plug

VIDEO INPUT

75 ohms unbalanced terminated internally
1 V. P-P Composite Video, negative going sync.
EIA or industrial sync.
UHF type input connector

VIDEO OUTPUT

75 ohms unbalanced 1 V. P-P Composite Video.
UHF type output connector

MODULATOR OUTPUT

Video modulated radio frequency output.
UHF type output connector
Tuneable through channels 2 to 5 for use with standard TV receiver
Nominal output 30 millivolts into 300 ohm load. Connects to TV receiver antenna terminals.

AUDIO INPUTS

Front panel switch
Selects:
a. balanced 200 ohms mife at .2mv minimum
b. 100K balanced bridging .12 to 4.9 volts
c. unbalanced bridging .12 to 4.9 volts
XL-type connector

AUDIO OUTPUTS

Rear panel switch
Selects either line or speaker, or both simultaneously
1. 600 ohm balanced or unbalanced line +4dbm nominal output +20dbm clipping level. XL type connector.
2. 8 ohms, 6 watt feeding internal speaker. Available externally at speaker jack.

VIDEO RESPONSE

30 cps to 3.5 MC +1db

AMPEX MODEL 7000, VIDEO TAPE RECORDER SPECIFICATIONS (CONT'D)

VIDEO SIGNAL TO NOISE

42 db, Peak-to-Peak signal to rms noise

HORIZONTAL RESOLUTION

350 lines limiting visual resolution on monoscope test pattern.

AUDIO RESPONSE

+4db, 50cps to 12KC

AUDIO SIGNAL TO NOISE

46db from peak record level

AUDIO FLUTTER AND WOW

Less than 0.15% rms. (measured according to ASA standards)

TAPE SPEED

9.6 ips

VIDEO WRITING SPEED

1000 ips

ROTARY HEAD LIFE

500 hrs.

Will require adjustment after 250 hrs.

Uses a single plug-in field interchangeable rotary head.

REWIND TIME

4 minutes (for 3000 ft. of tape)

FAST FORWARD TIME

14 minutes (for 3000 ft. of tape)

REMOTE CONTROL FACILITY

Remote play

Remote record

Remote stop

AMPEX MODEL 7000, VIDEO TAPE RECORDER SPECIFICATIONS (CONT'D)

TAPE

1" wide, 1 mil mylar base video tape
3000 ft. for 1 hr. recording time on 9-3/4" reel

CASE

Supplied in a heavy duty luggage type case with two handles and lid

SIZE

29" x 18" x 15"

WEIGHT

100 lbs.

OPERATING POSITION

Horizontal only

BELL AND HOWELL MODEL 2920 VIDEO TAPE RECORDER SPECIFICATIONS

GENERAL

TAPE

Standard 1-inch television tape (3M-351, or equivalent), A-wrap.

REEL TYPE

Standard MAB reel, 8 inches diameter.

RECORDING TIME

One hour with 8-inch reel containing 2150 feet of tape.

TAPE SPEED

6.91 inches per second.

RECORDING FORMAT

Each field of video information is recorded as a single and continuous track. Two audio tracks are standard. One audio track is used as a cue track.

START TIME

Color: 3 seconds maximum; Monochrome: 2 seconds maximum.

RUN-UP TIME

15 seconds maximum.

FAST FORWARD/REWIND TIME

90 seconds for one hour reel (8").

VIDEO HEAD

One, plug-in type.

MOTORS

Four: two induction torque and two hysteresis synchronous.

BELL AND HOWELL MODEL 2920 VIDEO TAPE RECORDER SPECIFICATIONS (CONT'D)

CONTROLS

TAPE MOTION CONTROLS

All tape motion is controlled by four pushbuttons: FWD, REWIND, PLAY and STOP. All controls are fully interlocked electrically, making it impossible to break, spill or throw tape. Functions can be remotely controlled with an accessory unit.

RECORD CONTROL

The normal record function, consisting of video plus audio, can only be initiated by simultaneously pressing the PLAY and RECORD pushbutton, when pressed, energizes the record circuitry which drops out when any tape motion control (other than PLAY) is pressed.

RECORD INDICATORS

When the cue switch is in the NORMAL RECORD position and the RECORD pushbutton is properly pressed, the indicator lamp above the RECORD button will light. In the AUDIO 2 ONLY position, the indicator lamp above the cue switch will light.

RECORD LEVEL CONTROLS

Video record level, audio 1 record level (main audio channel) and audio 2 record level (cue channel) are individually adjustable.

METERS

Two: video level and audio level. Audio level meter is switchable between audio 1 and audio 2 channels.

TRACKING CONTROL

The TRACKING control is adjusted to eliminate tearing of the reproduced picture.

TENSION CONTROL

The TENSION control is adjusted for minimum hook at the top of the reproduced picture.

COLOR LOCK CONTROL

The color lock control is adjusted to eliminate color banding of the reproduced picture

BELL AND HOWELL MODEL 2920 VIDEO TAPE RECORDER SPECIFICATIONS (CONT'D)

CONTROLS (CONT'D)

CUE SWITCH

In the NORMAL RECORD position, the audio 2 channel is recorded along with audio 1 and video. In the AUDIO 2 ONLY position, the audio 2 channel is recorded while monitoring audio 1 and video.

TIMER

Reads tape passage in minutes and tenths of minutes. The reset button next to the timer returns the timer to '000' when pressed.

VIDEO PERFORMANCE

BANDWIDTH

Black and White Output: 30 Hz to 3.5 MHz ± 1 db and less than 4 db down at 4.2 MHz. Color Output: Luminance: 30 Hz to 2.5 MHz ± 1 db, -3db; Chrominance: 3 MHz to 4.2 MHz.

SIGNAL TO NOISE RATIO

DIFFERENTIAL GAIN

Maximum deviation of 10 IRE units (10% to 90% APL).

INPUT LEVEL

0.5 to 2.0 volts.

INPUT SIGNAL

Any standard 60 field, monochrome or NTSC color signal. 75 ohm termination in recorder.

OUTPUTS

Two: one for monochrome and one for color. Both are adjusted for 1 volt composite video into 75 ohm line.

STABILITY

Horizontal Jitter: less than 0.5% of picture width with monitors of 7.5 millisecond horizontal afc time constant. Vertical

CROSSOVER

adjustable to hold within 5 microseconds.

BELL AND HOWELL MODEL 2920 VIDEO TAPE RECORDER SPECIFICATIONS (CONT'D)

AUDIO PERFORMANCE

NUMBER OF CHANNELS

Two standard.

BANDWIDTH

Channel 1: 75 Hz to 10 KHz \pm 4 db. Channel 2: 250 Hz to 7 KHz \pm 4 db.

SIGNAL TO NOISE RATIO

40 db both channels (relative to 3% distortion at 400 Hz).

INTERCHANNEL CROSSTALK

40 db minimum

FLUTTER AND WOW

Less than 0.25% rms.

INPUTS (both channels):

Microphone: 0.4 millivolts minimum, 200 ohms nominal. Line: -20 dbm to +16 dbm. (+4 dbm nominal) 600 ohms balanced or unbalanced.

OUTPUTS (both channels):

Adjusted for +4 dbm output into 600 ohm terminated line. +20 dbm clipping level.

MOUNTING AND POWER REQUIREMENTS

MOUNTING CONFIGURATIONS

Two: portable (supplied in carrying case) and unmounted (for rack mounting).

DIMENSIONS:

Uncased: 19 inches wide by 12 $\frac{1}{4}$ inches high by 9-5/8 inches deep (5 $\frac{1}{4}$ inches deep behind mounting surface including necessary clearance).

WEIGHT

Uncased: 57 pounds.

POWER REQUIREMENTS

110 to 130 volts, 60 Hz, 300 watts maximum

APPENDIX IV
APPROXIMATE EQUIPMENT COSTS

<u>Item</u>	<u>Unit Price</u>
Video Tape Recorder, Ampex Model YR 7000	\$3150
Video Tape Recorder, Bell & Howell Model 2920	4200
Camera, General Precision Laboratory, 700	1800
Zoom Lens, Canon 25-100 mm, f1.8, Model TV-16	425
Zoom Lens, Angenieux, 15-15 mm, f2.8	725
Pizar Lens, Kern-Paillard 25 mm, f1.5 (used)	70
Monitor, Miratel Model LV8M, 5" x 7" Screen	-
Contrac 23" Monitor, Model No. CVA 23	400
Tripod, Sampson, Model 7301	75
Tripod, Dolly, Sampson, Model 601	40
Lights and Accessories	
Vari-Beam 1000 Fixtures with Lamps, Model LQV-10	77
Multi-Broad, Variable Focus with Lamps, Model LQBM-10F	72
Light Stands on Coasters, Model SSBLLHA	28
Spun Glass Mtg. Ring	4
4 Leaf Barn Doors	17
Pole Kings & Accessories	15
Gaffer Grips	8
Carrying Cases	36
Video Tape for Ampex Recorder 100	42
Video Tape for Bell & Howell Recorder	36

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1. Ampex Corporation, Consumer and Educational Products Division. Ampex Operating Manual for Videotape Recorder Model VR-7000. Elk Grove Village, Illinois, 1966.
2. Bell & Howell, Tape Products Division. Owner's Manual Models 2910, 2910R, 2920, 2920R Video Tape Recorders. Chicago, Illinois.
3. Minnesota Mining and Manufacturing Company, Magnetic Products Division. Electrophotography Producers Manual. St. Paul, Minnesota, 1968.

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13. ABSTRACT A study was performed to develop new Personnel Subsystem Test and Evaluation (PSTE) techniques for use during Categories I, II, and III Testing of ground operator and maintenance type functions. This report is concerned with the development, modification, and refinement of a video tape recording system as a PSTE technique. Equipment and operational procedures developed for the technique were evaluated under various conditions including Category II Testing at an Air Force base. Results showed the utility of the video tape recording technique for design and procedures development and training functions as well as for PSTE. Specific recommendations are given for efficient use of this technique from system concept through operational use.		

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Category I, II, & III Testing Critical Task Identification Equipment Design Maintenance Assessment Personnel Subsystem Test and Evaluation (PSTE) System Development Testing Video Tape Recorder (VTR) Video Tape Recording Technique Video Tape Recorder Cart						

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